
A Dissertation
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Plagiarism Declaration

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GRADUATE SCHOOL OF BUSINESS

March 7, 2011

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Abstract

African Barrick Gold (ABG) is an offshoot of Barrick Gold Corporation (BGC); the global gold industry’s only A-rated balance sheet company with a market capitalisation of about $41B (as at June 4, 2010). BGC decided to spin off the African assets into a separate company by holding 75% share and floating the remaining 25% on the London Stock Exchange during the early part of 2010. The key strategic reasoning for this move was that, as an African company, ABG would be better positioned to generate shareholder value from its operating platform in Africa and would experience growth opportunities on the continent.

Within the last three years, cost of production for BGC/ABG mines in Tanzania has been increasing with a decreasing gold production. At the end of the third quarter of 2010 ABG reported that ounces of gold produced was 23% lower compared to the corresponding quarter of 2009 and Production cost was up by 32% for the quarter which is basically due to shortfall in planned production. In order to unravel the causal factors for this lower than expected performance, we need to go back to basics.

One of the key parameters in the mining process is the grade of material delivered to the processing plant. Grade to the plant from all the mines has been decreasing over the last three years, which is one of the main reasons why the company is not achieving its production target. The lower than expected grade to the processing plant may be caused by a number of factors. The activities pertaining to the mining of ore / waste from underground or open-pit and transporting same to the processing plant or waste dumps involves series of individuals and teams. There is an equally elaborate process route within the plant, for handling ore that has been received from mining and gold could be lost to tailings or not fully recovered purely because of the actions or inactions of certain individuals or teams.

The process by means of which the final and ‘true’ value, quality and quantity of a gold deposit, is evaluated from initial estimates by the geologist to the end of the process when bullion is achieved from the processing plant is called ‘Mine to Mill reconciliation’.
Reconciliation is a multi-disciplinary issue for which all the relevant professionals in the process must link and interact with one another to ensure that losses are minimised.

Currently there is no discussion forum to find reasons for the reduced grade and each of the teams within the production chain believes the estimates they provide are ‘true’. The issue of ‘who is right’ is a concern as there is lack of interaction and collaboration between the various teams. This research was undertaken to redesign the reconciliation management process by asking the question;

**How can a systemic approach improve the Mine to Mill Reconciliation process?**

The research begins with the Critical Realist philosophy that searches for the generative mechanisms, which that operate at a deeper level than the superficial constant conjunctures. At this stage nobody really knows what is causing the lower than expected grades. The research methodology employed in the study starts with Grounded Theory (GT) through data collection which takes place via a series of conversational interviews with professionals within ABG and Barrick. The responses were processed for which an underlying theoretical framework was formulated. The framework hinges on using meetings as a forum to manage the reconciliation process. These meetings have not been carried out effectively because of the perspective of the various stakeholders in the reconciliation management process. The Soft Systems Methodology (SSM) is a method that is well suited to the pluralist situation where there is the need to create some shared appreciation among stakeholders about what action needs to be taken to effect an improvement in a situation

The two methodologies led to the formulation of an answer that point to redesigning the current management processes to a holistic team-based management process by means of reconciliation meetings. In order to improve the meetings, the research stipulates the need to set up effective communication structures and garnering management involvement via shared management practices to ensure that the feedback process is carried through to the various levels of the production chain. Knowledge-sharing resulting from these meetings would lead to an effective feedback process that would assist both the technical and production teams to effect any changes and improvements that emerge. In a team-based approach where finance teams are represented, it would give them a better understanding and equip them to
accurately disclose the right information, with respect to the ‘true’ asset base of the company, to investors and analysts.

The answer was arrived at through a ‘painstaking’ process of interviewing and writing memos throughout the research period and though I had my own perspective on the issues, the insights gained from some of the interviewees were of great benefit with regard to my understanding of the problem. The combination of the GT, SSM and memoing helped in identifying the connections and dynamics of the various variables put together to arrive at the answer to the question dealing with ABG’s concern about lower productivity.

The research processes followed are credible, confirmable, dependable and transferable as the methodology used is based on actual interviews, GT process and following up with SSM. The theories generated are well documented in both the text and the references. It has been demonstrated that the systemic approach to derive an answer can be used to arrive at improvements in the reconciliation process in the gold mining industry in general.

In addition, the research investigates the ethical impact on the various stakeholders by instituting an effective reconciliation management process. The ethical evaluation of the proposal is based on a model that enquires into the utility, rights, justice and caring involved in any particular moral judgment.
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## Glossary of Terms

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<tr>
<td>ABG</td>
<td>African Barrick Gold</td>
</tr>
<tr>
<td>ACLD</td>
<td>Answer Causal Loop Diagram</td>
</tr>
<tr>
<td>AD</td>
<td>Affinity diagraph - a business tool used to organise ideas and data</td>
</tr>
<tr>
<td>Assay</td>
<td>A chemical test performed on a sample of ores or minerals to determine the amount of valuable metals they contained;</td>
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<tr>
<td>BI</td>
<td>Business Idea Model</td>
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<tr>
<td>Bullion</td>
<td>Precious metals in bulk form;</td>
</tr>
<tr>
<td>BOT</td>
<td>Behaviour over time</td>
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<tr>
<td>CLD</td>
<td>Causal Loop Diagram</td>
</tr>
<tr>
<td>CCLD</td>
<td>Concern Causal Loop Diagram;</td>
</tr>
<tr>
<td>Cut-off grade</td>
<td>The minimum metal grade at which material can be economically mined and processed (used in the calculation of ore reserves);</td>
</tr>
<tr>
<td>Dilution</td>
<td>Rock that is, by necessity, removed along with the ore in the mining process, subsequently lowering the grade of the ore;</td>
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<tr>
<td>Drilling (core)</td>
<td>A method that uses a rotating barrel and an annular-shaped, diamond-impregnated rock-cutting bit to produce cylindrical rock cores and lift such cores to the surface, where they may be collected, examined and assayed;</td>
</tr>
<tr>
<td>Exploration</td>
<td>prospecting, sampling, mapping, diamond drilling and other work involved in searching for ore</td>
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<tr>
<td>GFMS</td>
<td>Gold Fields Mineral Services (independent researchers of the gold market)</td>
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<tr>
<td>GT</td>
<td>Ground Theory</td>
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<tr>
<td>Grade</td>
<td>the amount of metal in each ton of ore, expressed as troy ounces per ton or grams per ton for precious metals and as a percentage for most other metals</td>
</tr>
<tr>
<td>ID</td>
<td>Interrelationship Diagraph - used to show cause-and-effect relationships between identified factors surrounding an issue</td>
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<tr>
<td>JORC</td>
<td>Joint Ore Reporting Committee of Australasia Institute of Mining and Metallurgy</td>
</tr>
<tr>
<td>Mill</td>
<td>A plant in which ore is treated and metals are recovered or prepared</td>
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for smelting; also a revolving drum used for the grinding of ores in preparation for treatment.

**Mine to Mill**
A process through which the final tons and grade of a gold deposit, is compared the estimated tons and grades

**Reconciliation**

**Ore**
A mixture of ore minerals and gangue from which at least one of the metals can be extracted at a profit

**Orebody**
A natural concentration of valuable material that can be extracted and sold at a profit

**Ounces**
Ounces (oz) (troy): used in imperial statistics; a kilogram is equal to 32.1507 ounces.

**Recovery rate**
The percentage of valuable metal in ore that is recovered by metallurgical treatment

**SAMREC**
The South African Code for Reporting of Mineral Resources and Mineral Reserves

**SSM**
Soft Systems Methodology

**Stope**
An excavation in a mine from which ore is, or has been, extracted.

**VSM**
Viable Systems Model

**Tailings (tails)**
Material rejected from a mill after most of the recoverable valuable minerals have been extracted
Acknowledgements

First, I would like to first thank Professor Tom Ryan who introduced me to UCT GSB some five years ago. This gave birth to systems thinking in me. To the rest of the supporting staff, Sherry, Julie and Trish I say, ‘Ahsante Sana na Mungu akubariki’.

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Finally, unto the King eternal, immortal, invisible -the only wise God, who by His grace made it possible for me to go through this journey, is to be honoured and glorified.
Chapter 1: Introduction & Overview

1.1 The Gold Mining Industry

Gold is produced from mines on every continent with the exception of Antarctica where mining is forbidden. The yellow metal is mined in developing countries including many of those designated as Heavily Indebted Poor Countries by the World Bank such as Ghana, Mali and Tanzania (GFMS 2010). For example mining, along with tourism and agriculture is one of the three pillars of Tanzania’s economy.

The performance of gold price during and after the economic crunch period has been impressive in the light of people trying to decrease their financial leverage. According to the 2009 World Gold Council report, gold was one of the few assets that genuinely provided investors with diversification throughout the financial crisis. During 2008, the gold price rose by 6%, while equities fell by 40%. In the first quarter of 2009, the gold price increased by 4%, while stock prices dropped by another 12%. During 2009 the gold price crossed the $1000/oz mark and from that period onwards shareholders expected the mining industry to produce to make them realise the margins they expect. The CEO of the World Gold Council, commenting on the gold price increase said that “Reaching the $1000 mark once again shows that this price level is no longer the watershed for gold that it once was (World Gold Council, 2009). The gold price continue to show a strong performance during Q2 2010, ending the quarter at US$1,244.00/oz compared with US$1,115.50/oz at the end of Q1 2010. This represented an increase of 11.5%, its largest quarter-on-quarter gain since Q1 2008. At the end of 2010, gold was trading at over $1300/oz.

The World Gold Council's 2010 September report on the gold market predicted that continuing strong demand from jewellery buyers in the two fast-developing markets of India and China, would help keep the price high (BBC News, 2010). It is interesting to note that at least 15% of annual gold consumption is recycled each year. In fact, gold has always been recycled - ever since it was first discovered in the Bronze Age. Your modern jewellery or dental crown may even contain some gold that was mined in prehistoric times and came from an artefact that had belonged to a king or emperor from an ancient civilization (Barrick Central, 2008).
1.1.1 African Barrick Gold

Barrick Gold Corporation is the gold industry’s only A-rated balance sheet company with a market capitalisation of about $41B (as at June 4, 2010). It is the largest gold producer, mining on four continents and to effectively execute its strategy and manage the operations, it has set in place Regional Business Units (RBU) for the following regions: Africa, Australia Pacific, North America and South America. Regional management oversees the day-to-day management of the mines and projects under development from feasibility through construction.

During the early part of 2010 Barrick decided to spin off its African assets into a separate company for which it decided to keep 75% of the share and floated the remaining 25% on the London Stock Exchange. The President and CEO of Barrick commenting on the spin-off said that "As an Africa-focused public company, we believe that African Barrick Gold will be better positioned to generate shareholder value from its operating platform, value from which Barrick will continue to benefit as a majority shareholder, ABG’s range of growth options and ability to finance those options will be expanded and the intensity with which these options will be pursued will be improved and will be driven by an incentivised management team, guided by an experienced Board of Directors”. Accordingly Barrick expects that as an Africa-focused public company, ABG will be better positioned to generate shareholder value from its operating platform and that its range of growth options and ability to finance those options will be expanded and the intensity with which these options will be pursued will be improved (Barrick Internal Communication, 2010).

The formation of the new company calls for strong strategic development processes which would eventually set the company up for success in the coming years as well as competing for mineral resources within the African continent. This therefore means that effective strategic decisions would have to be made. In addition, whatever strategic processes are set in place should be geared towards the success of the new company. Though it is ARBU that has metamorphosed into ABG, an effective change-management process must be initiated to set a new strategic outlook. ABG is currently made up of four operating mines – Bulyanhulu, Buzwagi, North Mara and Tulawaka all in Tanzania. Bulyanhulu is an underground gold mine; Buzwagi is an open-pit gold mine; North Mara consists of three open-pit deposits, and Tulawaka was an open-pit mine that has transitioned to an underground operation.
1.1.2 Gold Mining Production Environment

When most people think of gold mining, they imagine a prospector, panning in a stream. The reality is very different. Gold mining is a complex process that relies, more than most people would guess, on science, technology, expert thought, and stringent safety procedures. Gold mining activities consist of a complex interplay of professionals whose individual activities are inter-twinned. The output of one is the input of the other and these inputs are not in any linear order but flow in from a myriad of directions to be transformed into another input for the next stage up.

The process begins with the geologist who identifies the deposit by means of a series of mapping, drilling and interpretation. The geological data is the basis for the construction of a mineral resource model. The model is also the basis for mine development and its generation requires a thorough understanding of the geological settings of the deposit. Geology in the mining industry is paramount as there is no substitute for thorough geological interpretation of all the relevant resource data which provides the geological framework on which the project decisions are made (Duke and Hanna, 2001). The role of geology and its importance throughout the mining process is clear from the fact that geologists are involved from the exploration phase, through the estimation process to ensuring that the right material is delivered to the processing plant. The geologists also play a key role in reconciling the estimated and predicted to the actual. McCarthy (2001) notes that understanding of geology would reduce dilution (adding waste to ore material), Pease et al (2001) and Johnson (2001) notes the important role that geology plays in understanding mineralogical and ore characteristics of the material that is process through the processing plant to extract gold.

A strong understanding of geology and good resource estimation alone would not be sufficient to construct a mine unless mining engineers, metallurgical engineers, lawyers, environmental scientists, Human Resource, IT and the other associated professionals are involved. Non-geological disciplines should be involved at an early stage of the estimating process, particularly to ensure that the approach to resource modelling and estimation is consistent with the likely mining method (Laird, 2001). Data relating to contaminants or by-products or to mineralogical variations that will cause significant variation in metallurgical
performance needs to be collected and modelled (Moorhead et al, 2001). The ‘soft’ social, environmental and legal issues are increasingly important in the project assessment process.

A project that meets economic tests of viability may not be developed at all if its benefits are seen to be outweighed by the social costs. The concept of sustainable development is becoming important to the development decision. There is always the need to address community concerns and other relevant issues at each stage of the project’s evaluation and progress towards an Ore Reserve (Sharp-Paul, 2001).

Once the mine is operational, the geologists, mining engineers, mine planning engineers Maintenance engineers and process engineers form the production team within which the transformational processes are carried out with support from IT, HR, Supplies, Finance, Environmental, Community and Public relations. The transformation process begins with a plan that shows how much material would be mined and processed for the year or mine life which is further broken down into quarters, monthly, weekly and daily projections. The mine is judged on what it is able to achieve within a reporting period. This is what shareholders and resource analyst use to access the viability and profitability of a company. It is therefore important that, work within the transformational process is carried out in a manner that would produce what was planned.

The country in which the mine is situated also plays a key role in setting up regulations for operating the mine. In relation to ABG, the Tanzanian government, people and community
are key clients and stakeholders of the mine operations. Tanzania has been a classic success story in mining, with the adoption of an investor-friendly code in 1998 attracting a surge of interest, particularly in the prospective Lake Victoria Goldfields (Kafumu, 2004). The government of Tanzania would benefit from the mines being in the country if the mines produce the required ounces to generate the required royalties and also generate the right shareholder margins. The activities of the mining industry, especially those in developing countries are heavily monitored by numerous NGO’s. A typical mining work system is shown in Figure 1

1.1.3 Mine to Mill Reconciliation

One of the major activities that is carried out within the gold mining industry is reconciliation. This is a process by means of which the final and ‘true’ value, quality and quantity of a gold deposit, can be evaluated from the initial estimates by the geologist, to the end of the process when bullion is achieved from the treatment plant. The process amounts to more than simply comparing the ounces predicted by the geologist at the onset of the feasibility studies to the final ounces produced. It is about comparing an estimate against measurements at various points of the gold transformation processes. It is also the ultimate test for efficiency and the effectiveness of controls that are put in place for the entire production chain. There are several stages in the production chain where various types of reconciliation can be monitored.

The reconciliation process compares estimates of the Resource and Reserves to all the other estimates during production. The key comparisons are as follows.

- Resource model versus Grade control model – These two models are generated by the geologist but with a different sampling interval. The Resource model is usually based on a wide-spaced drilling data while the grade control is based on close-spaced sampling.
- Resource model compared with final gold bullion – This is usually a long-term view of what the project is to become with time. This gives either a ‘comfort’ or ‘warning’ as to what is to be expected over time.


- Reserve model to mine production – This applies to both long-term and short-term view of production. A big difference between the two informs of any issues between the geological interpretation and what is being achieved.
- Grade Control and the bullion – The variance gives the short-term to medium-term view of production. Grade control is meant to give a very close estimate of what is to be delivered from the plant.
- Reserve estimate to bullion – This is one of the most important checks in the reconciliation process as it validates, in the long term, the viability of the mine. It is the reserve estimate which is based on the prevailing economic conditions that determine the life of the mine. A comparison with the achieved bullion determines whether what is being predicted to be achieved over the life is realistic.

As shown from these comparisons, the process of accounting for variances involves a strong understanding of the various activities the gold bearing material goes through between two estimates. The focus of this report is the management of the mine to mill reconciliation which is one of the areas in the mining industry where a lot of concerns have been raised. Currently at ABG Mines in Tanzania, the practice has been each section/discipline to do the reconciliation pertaining to their area. The production team hardly ever come together to understand the reasons behind the variances.

1.1.4 Mining Production and Dilution

Over the last three years, cost of production for the mines in Tanzania has been increasing with a decreasing gold production. Production cost is mostly volume driven so if the ounce produced is lower, cost is usually high. At the end of third quarter of 2010 ABG reported that gold ounces produced were 23% lower compared to the corresponding quarter of 2009. During the quarter both Bulyanhulu and North Mara performed in line with expectations while production from Buzwagi and Tulawaka was below plan. The average grade for the quarter was 14% lower than that of the same period in the previous year. The decrease was primarily due to the processing of low grade ore at Buzwagi and Tulawaka whilst Bulyanhulu and North Mara were on track with planned production grades. Production costs were up by
32% for the quarter and up by 11% for the year which is mainly due to the fact that production was lower than planned (ABG, 2010).

Bearing in mind that ABG was created to harness the potential within Africa, the company needed to show that it could deliver on its inaugural target. The Buzwagi mine, which was commissioned late last year as a key player in the new company failed to deliver its target as indicated by the ABG third quarter report. The quarterly report indicated that the company was not in the position it would have preferred to occupy. This situation calls for the need to go back to the fundamentals in order to unravel the causal factors of the lower than expected grades at Buzwagi and Tulawaka. Though production from the other two mines was on target, the grades delivered to the processing plant were lower than expected. The situation that the company currently finds itself in is illustrated in Figure 2.
The geological team is responsible for controlling the grade that is mined to the processing plant and the geologists have to work with the other production team members such as the mining engineers, mine planners and the processing engineers. The geologist’s role in grade control is significant as he would first have to present a grade-control model to the mining engineer who, based on economics, would then determine how the orebody should be mined. The geologist makes sure that the area demarcated is mined and material sent to the appropriate designation - ore to the processing plant and waste to the waste dump. The geologist follows up with the processing team to ensure that the correct material blend required to feed the processing plant is achieved. However the work of the surveyor, the mine planning and the production engineer as well as the maintenance person and all the technicians, in one way or the other, comes in touch with the material during mining, hauling to the ROM pad and feeding into the crusher.

In addition to the technical team, the other professionals on the mine play a key role in the production chain. The IT professional must ensure that the information technology systems are optimally running while the Human Resource specialist needs to have set in place all necessary labour procedures and systems and must also have secured all the right people for the right jobs. It is important to note that when the grade delivered to the plant is lower than plan and production is lower than target, the impact is felt from the mine site right to the Senior Leadership Team (SLT)

### 1.1.5 Declining grade trend

One of the major areas identified as causing the delivery of lower than planned grades to plant is the inclusion of waste material (dilution). The other associated issue is leaving of ore in the walls, floors and roof of the stopes (Ore loss). At Bulyanhulu mine, for example, within the last three years the difference between the predicted grade (mine grade) and the Mill grade is increasing (Figure 3). This can be attributed to increased dilution from the stopes or ore material is left behind the walls of the stopes.
Figure 3: Bulyanhulu daily reported mined and mill grades over three years

At Bulyanhulu, every 5% of overall waste displaces the earning potential of $23.5M per year. In addition, every ton of waste brought to the surface generally costs the mine $67/t of direct costs for loading, hauling, hoisting, processing, and backfilling. A 5% dilution in the ore stream represents a direct additional cost of $3.7M per year. This shows that dilution has a bigger role to play in the high cost of production that is being experienced on the mine over the years. The process of adding waste to ore is not the fault of the geologist, or the mining engineer but it is the result of the inefficiencies of the various processes that results into such errors. This is one of the reasons why reconciliation is a multi-disciplinary issue for which all the relevant professionals in the process must link-up and interact with one another to ensure that dilution is reduced to the minimum.

Though the production target is ‘geared’ toward achieving a common goal, the individual KPI’s are different for each group and the approach to achieving the targets are different. These individual KPI’s creates a sense of self interest and a level of protectionism within the group in that the head of the group would do everything to protect and defend his/her team. This self interest tends to destroy the overall team dynamics as the teams would be hiding their ineffectiveness.

Another area that has an effect on the grade delivered to the plant is the measurement of metal recovery through the processing plant. AMIRA (2007) defines recovery of a particular component as the proportion of that component in the feed source, which is estimated to have
reported to each process stream but most commonly to the saleable product. Hence, recovery is a measure of performance efficiency and is always a key performance indicator. Because it is a measure of efficiency, it is easier for the metallurgical engineers to artificially increase the recovery and lower the grade as their KPI is not ‘heavily’ dependent on grade but on the recovery.

Within the mining, geology and process teams, supervision plays a key role in ensuring that the required grade is delivered and processed through the plant. Supervision is critical in ensuring that quality is achieved throughout the production chain. Any loss of control would create a ripple effect along the production chain which has multiplying effect as the material moves from one production team to the other. Most often lack of supervision and control are related to the level to which individual members interact and collaborate within the team. Any break in communication due to lack of collaboration within a team and between teams could create gaps that would severely affect the performance of the various teams. Another instance where negative collaboration would affect the grade delivered to the plant is when security personnel collaborate with ‘intruders’. This could result in these intruders taking the ‘eyes’ (high grades) of the material away leaving only low grade to be delivered to the processing plant. There was an instance where the lack of supervision and possible collusion resulted in the dumping of high-grade ore mined from the pit onto the waste dump. In another instance, mining operators, in their bid to aid theft, used to send ore material to the waste dump not for the material to be taken by intruders but as a way of getting the trucks to the dump for oil to be siphoned from their tanks.

Figure 4: Force field analysis on reducing grade
While problems from dilution, team dynamics, interactions, lack of supervision and recovery tend to lower the grade to the plant, the strong understanding of the geologic controls, sound estimation methodology and mining tend to improve grade to the plant as shown in Figure 4.

1.1.6 Dynamics of lowering grade

In order to understand the dynamics creating the lower than expected grade to the processing plant, the variables from the force-field analysis was processed through an Interrelationship Diagraph (ID) (see Appendix A) to identify the drivers and outcomes. This would lead to understand which of the variables are key requiring monitoring. Identifying key drivers would assist in identifying the right variables to be tackled first in order to measure success. The use of the ID allows for the identification and classification of the ‘cause-and-effect’ relationship between the variables causing the downward trend of grades delivered to the plant. Importantly the identification of drivers helps to classify and provide direction to solving the problems at hand. The process identified team dynamics, interaction and collaboration as the two key drivers that cause the lowering of grade to the plant by way of dilution, ore loss and Mill recovery.

The concern therefore is that lack of interaction and collaboration between the groups and teams severely affect grade delivered to the processing plant. This means that every effort needs to be put in place to encourage a positive team dynamics, interaction and collaboration within and between the teams to ensure that quality grade is delivered to plant. This will ensure the identification of any deficiencies in the production process for immediate corrective actions. This is the ultimate aim of the reconciliation process.

The variables were also used to construct a Causal Loop Diagram (CLD) to understand the dynamics at play from the variables and how they are related to one another. The generated CLD shows that there are two reinforced loops (Ro and Ra) at play as shown in Figure 5. Ro which is represented by the variables – The level of geologic understanding → accuracy of the estimation methodology → The Effectiveness of the mining method → Grade delivered to the plant → level of geologic understanding, is a positive reinforced loop helping to maintain, improve and correct any inefficiency in the technical aspects of the production process. The
loop Ra is a negatively reinforced loop that needs to be dealt with in order to make positive improvements in delivering the right grade to the plant. This loop is what has to be managed through the reconciliation process. The loop represents the degree of interactions and collaboration in a team which severely impacts on the team dynamics leading to poor controls and supervision. Poor controls and supervision leads to dilution and ore loss, resulting in lower than expected grade delivered to the plant. This linkage also negatively impacts on Mill recovery. In order to reverse the trend and ensure that improvements are set in place there is the need to create an environment that brings the teams together and ensure that any negative under tones are dealt with through the reconciliation process.

The dynamics of Figure 5 is my initial perspective of what needs to be rectified to reduce or reverse the concerned behaviour over time (CBOT) shown in Figure 4 which is causing a decline in grade delivered to the plant. It is important to put in place structures that would continuously improve the estimation, mining and processing of material in order to achieve the targets set by the company and to realise the expected shareholder margins. It is therefore necessary to look at the production chain holistically and ask the question;

**How can a systemic approach improve the Mine to Mill Reconciliation process?**
The situation at stake and the concern that there is lack of interaction and collaboration from the various teams means that if nothing is done, the organisation would destroy itself (Ackoff, 2001).

1.2 Understanding Systemic Approach

The lack of interaction is due to the way each team within the production chain pay attention to only their work area, although it is widely accepted that a high level of interaction between the various teams and departments determines the level of productivity in the industry. The company would benefit if these teams interact and deal with any situation systemically. The traditional way of reductionism that sees the parts as paramount and seeks to identify the parts, understands the parts and work up from an understanding of the parts to understanding the whole (Jackson, 2003) would not be able to solve complex problems for situations that exist in the mining industry. This is especially so if the issues relating to reconciliation where the geologists output becomes the mine planner’s input and the mine planner’s output later becomes the geologists and the mine production teams input are not addressed systemically. This ‘romancing the stone type activity’ ends up with the metallurgist who usually has the final say as regards the quality of the material delivered to the plant. The interdependence of one part on the other is so strong that it would be difficult to break the parts and try to work up from it.

According to Jackson (2003), the alternative to reductionism is Holism which is a system-thinking language that considers systems to be more than the sum of their parts. Though it is interested in the parts, it is particularly interested in the networks of relationships between the parts, primarily in terms of how they give rise to and sustain existence of the new entry that is the whole. Due to the fact that the mineral resource and ore reserves estimation process is an inter-disciplinary process, a systemic approach is the surest way that can be used to address any issues as well as improving the process of reconciliation. This is due to the fact that systems’ thinking is an interdisciplinary approach, it draws its ideas and concepts from a variety of disciplines and in so doing can draw on their different strengths.
It is important also to draw on the ‘work system’ concept as defined by Hoebeke in addressing the reconciliation management process. Hoebeke (2000) defines a work system as a purposeful definition of the real world in which people spend effort in more or less coherent activities for mutually influencing each other and their environment. The central theme of a work system is the transformation process in the definition. In this scenario, the transformation process is mining to processing. According to Hoebeke (2000), a transformation process expresses the purpose behind the work system and transforms a specified input into a specified output. The output must contain the input which has been transformed during the process.

Hoebeke (2000) addressed the issue of contribution and responsibility in his work systems theory which is relevant to the reconciliation process in that it emphasises the contributions that others make in the work system. Hoebeke noted that it is impossible to infer to which processes people contribute on the basis of their organisational position. It is only by defining the processes and their outputs that their activities can be discussed. Therefore in the reconciliation process, it is important to identify the contributions of each member in the value chain. Underlying the issue of contribution and responsibility is supervision across the entire transformation process. The work system as expressed by Hoebeke notes that it cuts across an organisation; it can thus be inferred that it also cut across departmental domains. Therefore the level of supervision should not be treated in isolation.

1.3 Management involvement in managing Reconciliation process

Referencing from Hoebeke’s contribution and responsibility concept, it is inferred that the operations manager is responsible for mining of ore to the plant. He or she would therefore have to understand the various activities performed by each of the departments he or she is responsible for. In addition, the Operations Manager would have to deal with and cope with all the issues relating to reconciliation. To deal with such situations, Ashby’s Law of Requisite Variety which states that to control a situation, is, to perform up to requirements, the variety of response actions must at least match the relevant variety of the situation (Espejo, 2000). For example in Figure 6, If we assume an existing situation between the pit geologist and the production engineer over for instance, the variance between the geologist
estimated grade and the mined grade; the Operations Manager requires a variety of 4 to cope with this situation since there exists four varieties here.

Figure 6: Requisite variety as a measure of complexity (adapted from T. Ryan, 2010)

According to Espejo (2000) variety proliferates at an extraordinary rate. For a group of just seven people, there are in the order of 4.5 million possible states for their interactions in time. Such numbers are so huge that they become literally meaningless, as people cannot make any useful sense of them. In this regard, imagine the complex computation and estimation of reconciliation process which also involves a large number of people and teams within the production chain, the General Manager would have to have the requisite variety to deal with any situation that would arise within the process.

In order for the organisation to manage complexity such as the reconciliation process, series of communication actions and programmes which attenuates and amplify variety will be required. The resultant performance will depend on the quality of the attenuation and amplification, which produce the balance identified by the Law of Requisite Variety. From Figure 7, the General Manager would have to manage the situation using the heads of departments who in turn does same through the superintendents.

Using the Japanese Jujitsu metaphor to explain the concept of matching variety with variety, Espejo (2000) noted that Jujitsu promotes the idea that strength is derived from understanding
what happens in a situation, which is where most complexity is seen to reside. This understanding can enable the actions of a smaller entity to stand up successfully to something much larger. Understanding a situation, through good models of the mechanisms for its self-regulation, is a useful way of dealing with its complexity. In order to understand the situation, the General Manager would have to create conditions for which the complexity is managed in small entities. In this scenario, the internal dynamics of each team in the production chain would have to be managed by the head of department which would allow the GM to manage the dynamics of the management team.

![Diagram of managing complexity within a production chain](adapted from T. Ryan, 2010)

In relation to the reconciliation process, there should be actions set in place such that heads of the teams meet on a regular basis to manage any situation that arises and feedback to the GM. Creating a new form of relationship between teams and within teams would create capacity for solutions to emerge from the people who participate in the processes by establishing conditions within which autonomous self-organisation and self-regulation are encouraged to flourish. Effective management uses the self-organising properties of social systems by reinforcing desirable activities and altering the environment or the reward structure to discourage undesirable ones (Leonard, 2004).
1.4. Establishing Relevance of the Research

The situation in context is the quality of material delivered to the processing plant and that the company over the first three quarters of its formation has had to reduce its production guidance to investors twice because grade expected to be delivered to the processing plant was not forthcoming. Prior to the formation of ABG, the African mines were managed by the ARBU which for the past three years also failed to achieve its production targets. Thus ABG not achieving its target is same as continuing with the ARBU performance. The question that is being asked is why ARBU and now ABG is not achieving its production targets.

The concern here is that with new shareholders and a new board, ABG needs to deliver on its set targets. There is the need to establish the reasons for the declining ore grades delivered to the plant from the mines which is the biggest concern. The consequences of delivering lower grade to the processing plant are that there is loss in revenue as well as increased cost. Using the Bulyanhulu mine’s example in which the addition of 5% more waste to the processing plant displaces earning by over $20M per annum. It is noted that this 5% dilution also has a ripple effect towards increased cost and time of mining. The other concern is that if production continues to decline due to lower grades and a corresponding increasing cost, investors and shareholders would lose interest in ABG which is listed on the London Stock Exchange and the company may also lose its place on the FSTE 100.

The relevance of this research is that for the company to establish the root cause of the declining grade problem, there is the need to manage the reconciliation process which basically aims (Morley and Thompson, 2006) at:

- Measure performance of the operation against targets,
- Confirm grade and tonnage estimation accuracy,
- Ensure valuation of mineral assets is accurate, and
- Provide key performance indicators.

The reconciliation process holds the key to unravelling any issues and problems within the production chain from geological estimation to processing of the ore into gold bullion. It is therefore relevant that such research be carried out. It is the process through which the final and ‘true’ value, quality and quantity of a gold deposit, can be evaluated as well as understanding the issues relating to any discrepancies in the production chain.
1.5 Structure and Overview of Research

The format of this report is built around the SCQARiE concept - Situation, Concern, Question, Answer, Rationale, implementation and Evaluation-. The Situation and Concern establishes the relevance of the research. The core of the research consists of the concern; the question and the answer (C→ Q →A) link establish the utility of the research whiles Answer and Rationale deals with validity of the research. Chapter 1 deals with the relevance of the research from the S→ C→ Q link which has been established above.

Chapter 2 reviews a selection of material that has a strong relationship to the research problem and explores relevant information that has been written or researched in the gold-mine industry with emphasis on grade estimation, dilution, reconciliation and management of the reconciliation process.

Chapter 3 outlines the research framework and methodology used to arrive at an answer that would address the research question. The framework comprises the philosophical foundation based on the Critical Realist view, data collection, Grounded Theory (GT) and review of various systems methodologies from which the Soft Systems Methodology (SSM) was chosen. GT and SSM were chosen as the main research methodology because the GT approach has an interactional element to it in that people within the industry were interviewed and their responses and the memos that were captured lead to a theory from the data. Similarly SSM captures the participant’s world view rather than that of the researcher, and therefore provides a basis to articulate a problem. The two methodologies therefore complement each other, because they both deal with human activity systems.

The results from the analysis of the GT process are presented in Chapter 4. The end product of the GT process is the theoretical code that was derived when the substantive codes were mapped onto Heijden’s (2001) Business Idea model to create a theoretical code - the dynamics of the variables established from the GT process-. The model provides a method to consider the future viability of a business proposition in all basic aspects that together make for longer-term success. The second part of the chapter outlines the use of the SSM results added to the theoretical code additional variables to create a dynamic framework (Figure 8) through which the reconciliation management process can be improved.
Figure 8: A framework to improve reconciliation management

The framework attempts to answer the question that would deal with the concern. It notes that an effective team-based reconciliation management system would have to be put in place to govern the process through reconciliation meetings. The meetings would inevitably permit the development of a proactive and continuous improvement approach to solutions with the attendant reduction or elimination of many invisible costs and risks. The combination of the results from the SSM process and GT creates consistency of purpose that would set in place the right communication structures to create the right information flow and align members of the management team. This would increase the level of shared management practices by improving team dynamics, interaction and collaboration that would lead to a higher degree of knowledge-sharing in the organisation. All these would be achieved when the team understands the importance of reducing waste to the processing plant and increasing the company’s revenue stream.

Chapter 5 is the conclusion and evaluation of the research for which the implication and significance is presented. The research is evaluated in terms of its Relevance, Utility and Validity. The validity of the research is evaluated in terms of its credibility, dependability,
transferability and confirmability. The ethical evaluation of the research recommendation is carried out using Velasquez’s four question models which inquires into the utility, rights, justice and caring involved in any particular moral judgment. Chapter 5 also deals with the limitation of the scope of the research in that the research is limited to reconciliation in the gold industry with data collected from ABG and global Barrick offices in North America and Australia Business units.
Chapter 2 Literature Review

2.1 Introduction

This chapter reviews a selection of material that has a strong relationship to the research problem under consideration. The essence of this chapter is to place the context of this research within the wider body of knowledge of reconciliation, and to establish the relevance and contribution that this research would add to the improvement of the management of reconciliation in the mineral resource industry. The literature review initially looks broadly at the estimation process upon which a mine is built, then looks at the role of geological control, dilution and the reconciliation management process. It also examines the reconciliation process and how it can be managed effectively. The key selected literatures used in writing Chapter 2 are presented in Append B.

2.2 Mineral Resource and Ore Reserves Estimation

In the gold industry, a ‘Mineral Resource’ is a concentration or occurrence of material of intrinsic economic interest in or on the Earth’s crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade, geological characteristics and continuity of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge (JORC, 2004).

An ‘Ore Reserve’ is the economically mineable part of a Measured and/or Indicated Mineral Resource. It includes diluting materials and allowances for losses, which may occur when the material is mined. Appropriate assessments and studies have been carried out, and include consideration of and modification by realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors. These assessments demonstrate at the time of reporting that extraction could reasonably be justified (JORC 2004). Depending on the geological and estimation confidence, a mineral resource is classified into Measure, Indicated and Inferred with Measured be the material with the highest geological and estimation confidence while Inferred is the least in confidence.
An Ore Reserve estimate is intended to provide a forecast of the tonnage and grade of material in a mineral deposit that will be processed to provide a saleable and profitable product. It is generally expected that the resource model on which the reserve estimate is based will provide reasonable predictions of the tonnage and grade of ore processed by the plant over a time period that is appropriate for medium to long-term planning and scheduling (Schofield, 2001).

Resource estimation techniques range in complexity roughly proportional to the amount of computation involved in deriving the estimate. The estimation process can only take place after the estimator is convinced of the soundness of the fundamentals underlying the process. Thus the database of sampling, density and other quality data for both estimation and geological interpretation must have integrity and robustness (Glacken and Snowden 2001).

Resource and Reserve estimation is not a matter of mere calculation but a procedure that involves – explicitly or implicitly – judgements and assumptions about geological, operational and investigative factors. The calculations therefore form only part, and not necessarily the most important part, of the overall procedure. In addition, an Ore Reserve statement should, where appropriate, be not merely an estimate of what is in the ground but a prediction, involving a further stage of judgement and assumption, of what will be fed to the mill and recovered (Mackenzie and Wilson, 2001). Detailed ore selection and scheduling in mining operations is usually based on the Grade Control model, which is created from additional sampling (Schofield, 2001). The entire estimation process and the various analyses are, as presented by Appleyard (2001), presented in Appendix C.

### 2.3 Geological Controls

A key factor in the development of the resource model is the synthesis of all available geological information derived from the interpretation of the resource database into a coherent geological model (Stoker and Gilfillan, 2001). This data forms the basis upon which major decisions are made and is also considered a key factor in future reconciliation processes. There is therefore no substitute for thorough geological interpretation of all the
relevant resource data, which provides the geological framework on which most project decisions are made (Appleyard, (2001), Duke and Hanna, (2001).

Carras (2001) notes that if there is one lesson to be learnt in the resource estimation process, it is the understanding of geological control and domaining to achieving correct resource estimates. The reality is that when geological interpretation is correct there is very little overall grade difference as a consequence of using the various methods of interpolation available. However, more often than not, when the geological interpretation is poor, none of the interpolation methods performs very well. Ore Reserve estimation is therefore not a mere calculation but a procedure that involves, explicitly or implicitly, judgement and assumptions about geological, operational and investigative factors. The calculations therefore form only part, and not necessarily the most important part, of the overall procedure (Mackenzie and Wilson, 2001).

The second model that brings in additional information is the grade-control model. Grade control is an important process for mining operations since the sole reason for the existence of the mine is to extract valuable mineral from the ground. As the first step of the beneficiation process, if grade control is not optimised, then no matter how good the downstream processes are the full potential of the operation will not be realised (Thornton, 2009). It is for this reason that beyond the grade control model, geologists have to ensure that dilution is reduced as much as possible.

2.4 Mining Dilution

Mining dilution results when waste material is mined alongside ore which lowers the overall grade of the material delivered to the processing plant. According to Stephenson and Vann (2001) dilution and mining recovery factors, while usually in the domain of the mining engineer, are largely dependent on geology, and should be decided in consultation with the geologist. However one fact noted by McCarthy (2001) is that in most cases when there are issues or dilution problems, the first people on the mine to be blamed are the geologists and especially the resource model upon which most of the economic decisions are derived.
Stephenson and Vann (2001) noted that since geological understanding is central to the estimation process, the earlier that some feel for the geology and detailed mineralisation controls can be gained, the better. It is for these reasons that Neuss (2001) noted that accurate ore boundaries are also important in defining the position of the ore in relation to the ore extraction plan and hence the dilution and ore loss that will be expected from the planned and unplanned dilution due to geological, mining and technical criteria. Non geological members of the production chain would therefore have to appreciate the complex geological controls on the deposit.

2.5 Mining Reconciliation

Reconciliation is all about comparing the Mineral Resource model, or Ore Reserve model, Grade Control information, or a mine production plan or schedule with a measurement (survey information, material movement records or the official production), usually from the processing or treatment plant (Morley and Thompson, 2006).

Reconciliation studies in most cases compare the predictions of Mineral Resources and Ore Reserves estimates, with the outcomes arising from subsequent mining and processing steps. There is a continuum of prediction and production steps ranging from exploration information, Mineral Resource and Ore Reserve estimation, through grade control and bulk sampling, to production, stockpiling and ore processing. Reconciliation studies test for internal consistency in the quality of data, prediction and execution at each step. This can reveal discrepancies between predictions and actual outcomes that may help improve future predictions. It may also provide early warnings for problems that can occur either in the predictions or in subsequent production steps. It follows that Mineral Resource and Ore Reserve estimates may be improved as a result of reconciliation studies (Gilfillan and Levy, 2001).

The basic aims of reconciliation are (Morley and Thompson, 2006) to:

1. Measure performance of the operation against targets
2. Compare predicted tons, average grade and metal predicted by the resource model or the grade control model to the tonnage processed and quantity of metal produced by the mill.
3. Ensure valuation of mineral assets is accurate.
5. Improvements in mining and in the estimation process.

Throughout the mine life the question (McCarty, 2001) that the mineral resource and ore reserve models answer are:

1. What percentage of the total resource tonnage will ultimately be mined?
2. How does the diluted tonnage delivered to the processing plant compare with the estimated resource tonnage?
3. What percentage of the total metal contained in the resource will be delivered to the processing plant?
4. What percentage of the resource (tonnage or contained metal) calculated at the resource cut-off grade will be mined (or delivered for treatment) at the chosen mining cut-off grade?

Once these are determined, the reconciliation process takes into consideration the level to which each of the monitoring stages should be addressed. In the entire monitoring process the variances between input and output are investigated to find reasons and understand what needs to be done with the results in order to facilitate any corrections in the estimation process or in mining. The entire reconciliation monitoring chain is represented in Figure 9 (Morley, 2003). This is a summary of a typical reconciliation process, from resource through to metal, and highlights key questions that should be addressed at various junctions throughout the process.
2.5.1 Reconciliation Monitoring Points

Following on from the work of Morley (2003), Morley and Thompson (2006) outlined eight main relationship monitoring points of reconciliation. The figure below presents a schematic process-flow summary of a generic mining operation from Resource estimation through to production of a commodity.
The reconciliation of Resource model to Grade Control (#1) is a check on the geological inputs from a wide-spaced drilling data for the resource model and the closed-space data for the grade-control model. It helps to improve on the Mineral Resource estimation processes. The item #6 in the table above compares the beginning of the process with the end. What is referred to as ‘Mine to Mill Reconciliation’ is the item numbered #7, which gives a reality of what was predicted and what was used to forecast the expected revenue for the mine.

Progress from one estimate to the other requires a number of other inputs, referred to as modifying factors. These factors include mining, metallurgical, cost and revenue, marketing, legal, location and financial inputs, all of which are fundamental to the determination of economic viability (Appleyard and Smith, 2001). The purpose of each of the comparisons shown in Figure 10 is detailed in Table 1.

Table 1: Key reconciliation relationship (After Morley & Thompson, 2006).

<table>
<thead>
<tr>
<th>Reconciliation</th>
<th>Data sources</th>
<th>Time frame</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Resource model to grade control</td>
<td>Resource model Grade control mining block designs</td>
<td>Monthly data showing annual trends</td>
<td>Used to validate resource model estimation and tonnage calculation assumptions. Long-term view with the objective of improving the quality of resource model estimates.</td>
</tr>
<tr>
<td>2. Reserve model to mine production</td>
<td>Reserve model Survey pickups Plant feed tonnes and grade</td>
<td>Monthly data showing annual trends</td>
<td>Used to validate reserve and design assumptions against actual mining practices. Long-term view with the objective of improving the quality of mine design parameters.</td>
</tr>
<tr>
<td>3. Mine production to grade control</td>
<td>Survey pickups Grade control model</td>
<td>Based on survey frequency, which should be at least monthly, but could be weekly or fortnightly</td>
<td>Used to compare what grade control designed to be mined and what was actually mined. Also allows taking of track factors. Short-term view to assist in improving grade control block design.</td>
</tr>
<tr>
<td>4. Mine production to plant feed</td>
<td>Dispatch tonnes Grade-Control Grades Plant feed tonnes Plant head grade samples</td>
<td>Daily data showing monthly trends and annual compilation</td>
<td>Used to validate grade control grade and tonnage predictions on a short-term basis. Assists in guiding daily mining activities.</td>
</tr>
<tr>
<td>5. Grade control model to plant production</td>
<td>Grade control model Survey pickups Plant commodity produced</td>
<td>Based on survey frequency, which should be at least monthly, but could be weekly or fortnightly</td>
<td>Used to validate grade control total contained commodity predictions to plant actual commodity produced. Medium-term view with the objective of improving grade control estimation techniques.</td>
</tr>
<tr>
<td>6. Resource model to plant production</td>
<td>Resource model Survey pickups Plant commodity produced</td>
<td>Normally monthly with annual trends</td>
<td>Used to validate Resource model total contained commodity predictions to plant actual commodity produced. Long-term view with the objective of improving resource model estimation.</td>
</tr>
<tr>
<td>7. Reserve model to plant production</td>
<td>Reserve model Survey pickups Plant commodity produced</td>
<td>Normally monthly with annual trends</td>
<td>Used to validate Reserve model total contained commodity predictions to plant actual commodity produced. Long-term view with the objective of improving design and scheduling parameters and assumptions.</td>
</tr>
<tr>
<td>8. Mine plan to actual mined</td>
<td>Budget/forecast/schedules Dispatch Grade control grades</td>
<td>Daily data showing monthly trends and annual compilation</td>
<td>Used to show variance to plan. This can be achieved in a number of different ways – but the authors recommend using Dispatch so that variances can be tracked on a daily basis. Short- to medium-term view with the objective of improving mine planning.</td>
</tr>
</tbody>
</table>
2.6 Management of Reconciliation

The nature of the reconciliation with respect to data source, time frame and purpose, as outlined by Morley & Thompson (2006), requires a team effort to ensure that each of the measuring areas is done correctly. In addition, it is important that the geologist who starts the process needs to have a strong understanding of the geological controls on the mineralisation being interpreted. Without a sound geological understanding, and a sensible application of that understanding, an estimation exercise becomes merely a mathematical treatment of sample results with no practical value. More seriously, any result that does not take sufficient account of geology is almost certain to give a seriously misleading impression of the value of the deposit (Stephenson and Vann, 2001). Geological interpretation involves the recognition of the critical components of a deposit, their distribution, variability, continuity and, if possible, their genetic controls. It is the first stage in the transformation of data to a three-dimensional model that will form the basis for Mineral Resource estimation (Mackenzie and Wilson, 2001). The geologist must also make a prudent assessment of the quantity and quality of the data (geological, sampling, etc) upon which the interpretation is based and convey to other involved parties an appreciation of any uncertainties attached to the data. This is critical for both the selection of the estimation method and for resource/reserve classification at a later stage.

The Mining Engineer is a key member of the Ore Reserve estimating team, but should also be a member of the Mineral Resource estimating team. At both stages, there are a number of aspects where close communication and agreement between the geologist, geostatistician and mining engineer are required. It is more important to the value of the final result that the Metallurgist has a close involvement at all stages of the drilling and sampling programmes upon which the estimate is based, in order that the necessary mineralogical and metallurgical investigations are carried out in a timely and logical fashion (Stephenson and Vann, 2001).

One of the assumptions that underpins the confidence placed in the use of mine reconciliation as a measure of the performance of resource and grade control models, is the assumption that the mill is able to measure the grade and tonnage of the material processed with more accuracy than the resource estimation procedure or grade control procedure. This assumption can be a bone of contention in mining operations. After all, the grade reported by the mill is often only another estimate based on sampling of a blended mill feed and the mill tailings
(Schofield, 2001). It is therefore one of the reasons why the management of mine to mill reconciliation should be carried out by means of a team-based approach.

2.6.1 Communication and Teamwork in Reconciliation Management process

Due to the highly technical nature of the estimation process, it is the responsibility of the technical team to communicate to management not only the result, but also the data and assumptions upon which the results are based, and the degree of confidence in the final figures (Stephenson & Vann, 2001). It is also important to note that any multidiscipline team is likely to create tension in accountability by storming, norming, forming and finally performing. Therefore the ability to recognise and respect the differences that exist within each of the groups and teams as well as appreciate the contribution that each member brings to the process is invaluable. In order to reach this consensus the team needs to create a climate of dialogue that shifts from blame to learning (Fitzsimmons and White, 1997). McCarthy (2001) reckons that face-to-face communication between the geologists and other members of the team are essential for the geologist to explain any inherent limitations of the models. The emphasis on the geologists in reconciliation issues is as if they are responsible for all the negative variance between the predicted grade and the final achieved grade.

Appleyard (2001) is however of the view that good communication between the geologists in an estimating team; between the geologists and the other disciplines; between the estimating team and management; and between the owners and their various stakeholders is essential for effective estimation, use and management of resources and reserves. The issue is so important that, through all the stages of estimation, evaluation and operation, part of a senior manager’s responsibility should be an awareness of all developments related to resource and reserve estimates, and communicating their status to all other relevant parties.

In a process where the input for one profession is the output of others, the need for teamwork and collaboration is critical. This is one of the reasons why Barrick states as one of its core values: ‘Be a Team player’ and notes that: “We work safely at all times. We respect our colleagues and those we interact with outside our organisation. We listen to others for understanding and we ask for help. We build trust and celebrate our successes. We help
others improve their effectiveness. We promote confidence and trust in each other’s capabilities. Conti and Kleiner (1997) support the importance of teamwork as individual effort is less efficient than the collaboration of several individuals’ creativity. In situations that require a combination of multiple skills, experiences and judgements, a team would achieve better results than would individuals working within confined job roles. Team spirit, or the sense of loyalty and dedication, brings together a group of individuals and develops a team that is committed to its goals.

Adams et al. (2002) identified seven characteristics of team effectiveness as the main elements that need to be present in a team in order for that team to be effective. These characteristics are productive conflict resolution, mature communication, role clarity, accountable interdependence, goal clarification, common purpose and psychological safety. Of these characteristics, common purpose and mature communication are vital for an effective reconciliation management process. It is however worth mentioning that the degree to which a group’s output meets requirements in terms of quantity, quality and timeliness (performance); the group experience improves its members’ ability to work as a group in the future (behaviour), and the group experience contributes to individual satisfaction (attitude) (Hackman, 1990). Thus team effectiveness is a function of performance, attitude and behaviour.

2.6.2 Effective Reconciliation Meetings

Communication and teamwork though, are vital for effective reconciliation management; and there is the need to have a forum where members of the team would meet to discuss reconciliation issues. Such forums should be held in a meeting-like atmosphere. According to Boden (1994) a meeting is a planned gathering, whether internal or external to an organisation, in which the participants have some perceived role, have some forewarning of the event, which has itself some purpose or ’reason’, a time, place and, in some general sense, an organisational function. Schwartzman (1989) also defines meeting as a communicative event involving three or more people who agree to assemble for a purpose ostensibly related to the functioning of an organisation, to exchange ideas or opinions, to solve a problem, to make a decision, to develop policies and procedures. A meeting is characterised by multi-
party talk that is episodic in nature, and participants either develop or use specific conventions (Jarzabkowski and Seidl, 2006). The participants engage in institutionally specific activities and typically orient to achieving certain goals in the form of decisions, agreements, solutions, or ideas (Asmuß and Svennevig, 2009). In contrast to ‘turn talk’, Asmuß and Svennevig (2009) noted that meetings constitute a fundamental site for enacting institutional roles and relationships. In the case of a reconciliation meeting, the participants would generally be constituted by the production team leaders (such as head of geology, mining, processing, finance and sometimes engineering).

Managers spend a large percentage of their time in meetings, but traditional, verbal meetings are often inefficient and ineffective (Aiken et al, 1994). The most effective meeting process requires exploitation of the group as a resource, and that only happens if leaders manage their own maintenance roles more effectively (Myrsiades, 2000). The level of participation in meetings is most important; however, there are some members who come to meetings either not prepared or apathetic, which Sveiby (2007) considers to be a disabling behaviour, saying that apathy is not innocuous; it communicates an unspoken value statement, i.e.: the issue is unimportant and not worthy of attention. Reconciliation meetings, if run effectively, should serve as the arena for which knowledge would be shared within the group.

2.6.3 The importance of Knowledge sharing

The future success of a company is affected by how efficiently it can convert one form of value into another and, considering this point, that intangibles increase and provide leverage through deliberate action (Allee, 2008). Thus the four strategic resource qualities: value, rarity, inimitability and non-substitutability, are intangible assets (Wills-Johnson, 2008). The study of knowledge sharing, which is the means by which an organisation obtains access to its own and other organisations’ knowledge, has emerged as a key research area from a broad and deep field of study on technology transfer and innovation and, more recently, from the field of strategic management. Indeed, experience and research suggest that successful knowledge sharing involves extended learning processes rather than simple communication processes, as ideas related to development and innovation need to be made locally applicable with the adaptation being done by the ‘incumbent firms’ (Cummings 2003).
Knowledge sharing has become an important focus in the strategic management field, where knowledge is seen as ‘the most strategically important resource that organisations possess for which it is now considered as a principal source of value creation,’ (Cummings, 2003). In many organisations, the importance of developing abilities to better utilise the knowledge contained in the firm’s network has become apparent. Benchmarking has demonstrated the potential benefits of best practices transfer. Instances of failure in downsizing, on the other hand, have revealed the costs of losing knowledge. Hoffman et al. (2005) believe that sustained competitive advantage occurs when a firm develops a distinctive core competency such as knowledge management. Monnavarian and Amini (2009) are of the view that exchange of information is one of the key embedded factors of improving teamwork morale, and Cummings (2003) believes that a successful knowledge-sharing effort requires a focus on more than simply the transfer of the specific knowledge. Instead, many of the activities to be undertaken need to focus on structuring and implementing the arrangement in a way that bridges both existing and potential relationship issues, and examining the form and location of the knowledge to ensure its complete transfer. In other words, while the activities used to share knowledge, such as document exchanges, presentations, job rotations, and so on., are important, overcoming the factors that can impede, complicate and even harm knowledge internalisation are equally important in determining the ultimate results of a knowledge-sharing effort. The creation and application of new knowledge, especially during reconciliation meetings, is essential to the survival of the businesses in that ideas, processes and information are currently taking a growing share of global trade from the traditional, tangible goods of the manufacturing economy. Increasingly, the only sustainable competitive advantage is continuous innovation. To create a knowledge-sharing culture you need to encourage people to work together more effectively, to collaborate and to share and, ultimately, to make organisational knowledge more productive (Gurteen David, 1999). The production team members would have to work together for the full benefits of putting in place a good governance process for reconciliation.
2.7 Conclusion

Most researchers on Resource estimation, dilution and reconciliation management agree that to effectively manage reconciliation, one needs to have all the teams talking to one another, making this a team-based approach. QGroup (2006) commented that a well-implemented and managed reconciliation can have a material impact on a mining company’s bottom line. Understanding the mining value chain, and identifying points along the chain where potential value is lost, allows corrective action to be taken. Reconciliation is only worthwhile if it results in changes that improve performance.

A valuable property of a properly functioning reconciliation system is that it will measure its own performance and improvement. Thus reconciliation is a cornerstone of continuous improvement in mining and it is difficult to imagine system-wide improvement without good reconciliation systems. When monitored on a regular basis, the reconciliation process will uncover problems with grade and tonnage estimation, sampling, mining methods, processing problems and a host of other technical problems (Morley and Thompson, 2006).
Chapter 3.0 Research Framework and Methodology

3.1 Introduction

The research framework was crafted by first looking at the goals of the research and the issues at stake. The goal of the research is to understand how the management of the Reconciliation process can be redesigned using a systemic approach. This is due to the fact that the grade to the processing plant is declining, which affects the revenue stream of ABG mines in Tanzania. This is evidenced in the last three years’ production reports for which cost of production is increasing with a decreasing gold production. In order to understand the issue of lower than expected grade delivered to the processing plant, there is the need to compare estimated and predicted grades to that achieved by the mill. This is the reconciliation process that compares predicted tons, grade and ounces to the actual gold bullion achieved from the mill. However, over the years, the management of this reconciliation process has not been optimal, which then makes it difficult to understand the cause of the decreasing grades from mining to mill. A schematic representation of the research design, which is made of the research goal, conceptual framework, methods and validity is presented in Appendix D.

This chapter outlines the research framework and methodology that would be followed to understand the causal mechanism underlying the declining grade delivered to plant, and how a systemic approach can be used to understand the underlying causal mechanism from which an answer to the research question that was posed as:

**How can a systemic approach improve the Mine to Mill Reconciliation process?**

3.2 Philosophical Foundation

The philosophical base for this research is that the decline in grade cannot be attributed purely to the statistical variance between the estimate and the actual grades delivered to the plant. There is however a causal mechanism that is assumed to exist, that needs to be explained in order to find a solution to it. This is called Ontology, which is defined as the philosophical study of the nature of being in existence or reality in general, as well as the
basic categories of ‘being’ and their relationship with one another. Ontology deals with questions concerning what entities exist, or can be said to exist, and how such entities can be grouped, related within a hierarchy, and subdivided according to similarities and differences (Wikipedia).

Epistemology or theory of knowledge is the branch of philosophy concerned with the nature and scope (limitations) of knowledge (Wikipedia). It addresses the following questions:

- What is knowledge?
- How is knowledge acquired?
- What do people know?
- How do we know what we know?

A distinctive feature of a realist philosophy is that ontology is seen as distinct from epistemology, which means that scientific theorising is based on the assumption that there exists a mind-independent reality (Wikgren, 2005).

### 3.2.1 Critical Realism

The critical realist position claims the existence of ‘reality’ while emphasising the relativity of our knowledge of it as always being theory-dependent (Aastrup and Halldorsson, 2008). A feature of critical realism is its emphasis on the search for generative mechanisms, which might operate at a deeper level than the superficial constant conjunctures which positivists’ mistake for cause and effect. That is, realists look at each level for the causal mechanisms which are at work (Mutch, 1999). Critical realists are of the view that there are unobservable underlying events causing the observable.

To the critical realist, the first form of stratification occurs between the underlying mechanism and the events they generate and the subset of events they generate, which is seen in the empirical world. For example using geological principles as shown in Figure 11, underlying oceanic reactions might be the cause of eruptions of volcanic activities that result in the formation of mountains and valleys, which are observable in empirical terms. From a basic sociological process, the social world can be understood only if people understand the
structures that generate such observable events. In the management of reconciliation, we can only understand the reasons why grade is declining by understanding the causes that lead to the current situation.

Figure 11: Critical Realism stratified domains.

CR holds that, ‘we will only be able to understand the social world if we identify the structures at work that generate those events and discourses. These structures are not spontaneously apparent in the observable pattern of events; they can only be identified through the practical and theoretical work of the social sciences,’ (Carlsson, 2003). Critical Realism is a form of Epistemological Dualism (the object out there and the idea in the mind) because it subscribes to the view that there is both a mental world and an objective, outside world. Knowledge about the outside world may not always be possible and may often be imperfect, but nevertheless it can, in principle, be acquired and it is essentially different from the mental world of our minds (Cline, 2010).

As shown in Figure 11, the critical realist views the world as existing in stratified forms (layers) which are:

1. Real: (What caused the happening) – this is everything that exists in nature and consists of the process, structures, powers and causal mechanism that generate events.
2. Actual: (What has happened) – the event or activity, whether observed or not, that are carried through generating the effects of power.

3. Empirical: (What we perceived) – this is the domain of experiences and the observation of events.

The intent of this research is to have a thorough understanding of the causal mechanism that has led to the fact that current management of reconciliation is not optimal. The primary focus for the realist is to identify the underlying objects of research, which then helps to define approaches that should be adopted.

Critical Realists also adopt the retrodution strategy, which is based on the following steps (Systal, 2010CR):

(i) Research begins in the domain of the Actual with observed connection between phenomena. The task is to explain why such connections or relationships occur.

(ii) Postulate the existence of real structures and mechanism which, if they exist, would explain the relationship.

(iii) Demonstrate the existence and operation of these structures and mechanisms. The central problem is to establish the plausibility of hypothesised structures and mechanisms, given that they are not immediately available to experience.

The critical realist seeks to reconstruct causal structures and their properties on the basis of constant reflections and imminent critique (Yeung, 1997). For the realist the purpose of a study (intensive, abstract or generalisable research) helps to define the particular underlying aspects of reality upon which the realist researcher should concentrate.

There are three methodological approaches to address or investigate phenomena from critical realist point of view (Yeung, 1997). These are:

1. Use of iterative abstraction
2. Grounded Theory method
3. Use of Triangulation

In this research, the Grounded Theory Method is used because it is a method that develops a theory from analysed data that was collected within the domain of the research.
3.3 Methodology

The methodology followed, based on the critical realism philosophy, is via data collection, GT and a selected systems methodology that can be integrated with GT to arrive at an answer that would deal with the research question.

3.3.1 Data Collection

The data collection stage began with one-on-one conversational interviews, which were conducted with key personnel within ABG and in the mining industry. Conversational interview is a semi-structured interview of which there is always a topic around which the conversation takes place. A concept map that outlines the process of a conversational interview structure is presented in Appendix E. Conversational interviews are designed and set up in such a way that the respondents understand questions being asked by the interviewer who helps the respondents by interpreting the question for them. In this scenario the conversation starts with an overview-type question relating to the general management of reconciliation. The interviewee can choose to discuss issues within one particular transformation process (e.g. he or she could discuss issues relating to geology or mining). This is a process where there is a need for total collaboration from both parties, as well as a sense of mutual interest.

The conversation was held in a non-intimidating manner to allow for easy flow of information to be gathered. The key point for the conversation was to gather empirical data from the realist point of view. The Grounded Theory methodology was used to analyse the data captured. Data saturation and triangulation was carried through additional interviews and literature reviews. A description of the GT process is presented below and it is worth mentioning that although the process may seem to be following from one stage to the other in a linear function, there was a continuous interplay back and forth between data collection and analysis. It is a process where the researcher begins analysing the data right at the start of the research period.
3.3.2 Grounded Theory

GT, which is also called ‘the discovery of theory from data’, aims to generate theory by grounding that theory in data rather than verify theory, as traditional quantitative research does (Tan, 2010). GT refers to theory that is developed inductively from a corpus of data. It is a way of thinking about data towards a goal of developing a theory grounded in the empirical substance of the social area. GT is thus a qualitative research methodology that explores Basic Social Process (BSP) and is one that is inductively derived from the study of the phenomenon it represents (SYSTAL 2010). GT moves from the specific to the more general. The method of study is essentially based on three elements: concepts, categories and propositions. However, concepts are the key elements of analysis since the theory is developed from the conceptualisation of data, rather than the actual data. Data collection, analysis and theory formulation are undeniably connected in a reciprocal sense, and the grounded theory approach incorporates explicit procedures to guide this.

The uniqueness of the GT approach from other qualitative research approaches lies in four elements as follows (Tan, 2010):

- Theory is emergent from empirical data rather than from inferences or existing theories.
- The constant comparison method enables theory generation during systematic collective and analytic procedures.
- Memo writing is the formulation and revision of theory throughout the research process.
- The research process is flexible and creative.

According to Tan (2010), GT aims to generate core concepts and develop a theoretical framework that specifies their interrelationships. It calls for qualitative tradition built on five canons:

- Theoretical sampling;
- Coding;
- The constant comparative method;
- Categorising and category saturation (Substantive coding); and
- Theoretical Coding
In any GT study, several theoretical codes may emerge but eventually, through ongoing coding and memoing, one theoretical code is chosen as the theoretical code for the study. A GT study’s theoretical code is the relational model through which all substantive codes/categories are related to the core category. In GT methodology, substantive codes conceptualise the empirical substance of the area of research. Theoretical codes conceptualise how the substantive codes may relate to each other as hypotheses, to be integrated into the theory. It is important that Theoretical codes must not be preconceived, rather they are emergent in the data and therefore earn their way into the theory as much as substantive codes (Hernandez, 2009). Several theoretical codes can be discovered as coding proceeds during one GT study. However, discovery of the ultimate theoretical code that integrates the substantive theory will probably occur during the selective coding phase, that is, after the core category has emerged. The theoretical code that ultimately emerges as the one that most fully integrates the substantive theory is one that specifies the overall relationship between the core category and all other categories.

The GT processes is presented in the figure below

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**Figure 12: The Grounded Theory process.**
The theory that is developed from the GT process is from the researcher’s perspective, based on the data collection. The significance of the research result would be enhanced if the perspectives of the participants are also intertwined with the theory to produce a workable strategic framework to deal with the research question and problem. In this case, the researcher would be looking at a holistic view of the problem at stake. It is also important to reaffirm the fact that the question posed for the research is:

**How can a systemic approach improve the Mine to Mill Reconciliation process?**

With respect to a systemic approach to the reconciliation process, there is the need to find out which of the systemic methodologies that can be integrated with GT to arrive at an answer that would answer the research question and deal with the declining grade situation. A review of the various systems methodologies that can potentially be used in this research is presented.

### 3.3.3 Systems Methodologies

Jackson (2003) outlines four different holistic approaches that would help management in dealing with any situation using systems thinking methodologies. The identified approaches are:

1. Systems approaches for improving goal seeking and viability
   a. Hard Systems Thinking
   b. Systems Dynamics
   c. Organisational Cybernetics
   d. Complexity Theory
2. Systems approaches for exploring purposes
   a. Strategic assumption surfacing and Testing
   b. Interactive Planning
   c. Soft Systems Methodology
3. Systems thinking approaches for ensuring fairness
   a. Critical Systems Heuristics
   b. Team Syntegrity
4. System thinking approaches for promoting diversity.
   a. Total Systems intervention
   b. Critical Systems Practice

Jackson (2003) further noted that it is more holistic to believe that improving organisational performance, in its broadest sense, requires an ability to look at the organisation from all the above holistic approaches. However, it is important to note that overall organisational performance must depend on: improving goal seeking and viability; exploring purpose; ensuring fairness; and promoting diversity. Consideration therefore must be given to efficiency, efficacy, effectiveness, elegance, emancipation, empowerment, exception and emotion. Improvement can involve all of these although it is necessary for managers to prioritise and have a different emphasis to their action at different times.

The issue that the research is attempting to solve can be considered as exploring the purpose for which grade is declining and to understand the impact of the activities of the various individuals that are involved in the mining transformation process. Therefore a brief look at the three methods under Systems approaches for exploring purposes is evaluated below, from which one of the methods would be used with GT to arrive at an answer to the research question.

**Strategic Assumption Surfacing and Testing (SAST)**

SAST is a systems methodology that is employed when managers and their advisers are confronted by ‘wicked’ problems (a problem that is unstructured and the nature of which depends on the perspective of the various stakeholders). In tackling a wicked problem, problem structuring assumes a greater importance than problem solving using conventional techniques (Jackson, 2003). SAST is a process that reveals the underlying assumptions of a policy or plan and helps to create a map for exploring them (Manson and Mitroff, 1981).

SAST incorporates the following principles:

1. Adversarial: based on the premise that the best way to test an assumption is to oppose it.
2. Participative: based on the premise that the knowledge and resources necessary to solve and implement the solution to a complex problem is distributed among a group of individuals.

3. Integrative: based on the premise that a unified set of assumptions and action plans is needed to guide decision-making, and that what comes out of the adversarial and participative elements can be unified.

4. Managerial mind supporting: based on the premise that exposure to assumption deepens the manager's insight into an organisation and its policy, planning and strategic problems.

According to Jackson (2003) there is little evidence in favour of the superiority of SAST over more conventional planning approaches due to the fact that the method was designed to assist and deal with ‘wicked’ problems. However SAST is a methodology that can encourage and orient a participative style of problem management.

**Interactive Planning (IP)**

Interactive planning is directed at creating the future. It is based on the belief that an organisation's future depends on what it does between now and then, as opposed to what is done to it. Therefore, this type of planning consists of the design of a desirable present and the selection or invention of ways of approximating it as closely as possible. It creates its future by continuously closing the gap between where it is at any moment in time and where it would most likely be (Ackoff, 2001). IP is based on three main principles:

- Participation
- Continuity
- Holism

Interactive planning takes place by engaging in the planning process to such an extent that participants come to understand their organisation and its environment and how they can direct it towards a future they jointly desire. Involving people within the organisation and allowing them to participate in the planning processes increases ownership of the plan, which everybody would ‘buy’ into. Continuity refers to continuously improving on the system that is set in place.
Ackoff noted that there are five phases of interactive planning processes:

1. Formulating the Mess
2. Ends Planning
3. Means Planning
4. Resource Planning
5. Design Implementation and Control

The IP approach facilitates the participation of all stakeholders in the planning process and therefore secures the main benefit of planning. In this research however the main goal is redesigning the process and not a major planning process. However one can use the IP process to formulate the problem at stake by determining the future of the organisation if nothing is done to the issue.

**Soft Systems Methodology (SSM)**

SSM is essentially an action research methodology intended to bring about improvement. Through the processes of modelling, iteration, reflection and negotiation it draws together different perceptions, assumptions and points of view of different people who are involved in a problem situation in a cycle of learning. SSM expresses the situation in which a perceived problem exists in terms of structure and processes and the relation between the two, rather than as a clearly defined problem (Barry and Fourie, 2001).

SSM is based on some clearly defined activities that guide the process of intervention in ill-structured situations and the aim of the method is to structure a debate that will lead, if not to the creation of a shared perception, at least to an accommodation between different viewpoints and interests so that a desirable change can be implemented. SSM is well suited to the pluralist situation where there is a need to create some shared appreciation among stakeholders about what action needs to be taken in order to bring about improvement in a situation (Jackson, 2003).

The SSM method offers an excellent way to explore purpose using human activity system models to discover what is possible given the history, culture and politics of the problem situation. In addition, the method articulates a learning system that challenges existing ways
of seeing and doing things (Jackson, 2003). The method makes use of some powerful methods such as rich picture, root definition (which is captured through CATWOE) and conceptual models. There are seven stages in the SSM process, which are captured in Figure 13 below.

![Diagram of the SSM process](image)

Figure 13: Steps in the SSM process (Adopted from Finegan, 2010).

### 3.4 The Choice of Methodology for the Research

The Soft Systems Methodology (SSM) was selected for this research due to its intervention in ill-structured problem situations where relationship maintaining is at least as important as goal-seeking and answering questions about ‘what’ we should do, is as significant as determining ‘how’ to do it (Jackson, 2003). The aim of SSM is to structure a debate that will lead, if not to the creation of shared perceptions, at least to an accommodation between different viewpoints and interests so that a desirable change can be implemented. For ABG, it is important to have all the various professionals within the production chain sit together and discuss issues arising from the reconciliation process to ensure an agreed improvement
process is set up for the organisation, which would be monitored to ensure continuous improvement. This is due to the fact the SSM offers an excellent way of exploring purpose, using human activities systems models to find out what is possible given the history, culture and politics of the problem situation.

The SSM methodology captures the participant’s world view rather than that of the researcher and therefore provides a basis to articulate a problem. It is therefore best suited to be paired with the GT theoretical code to establish a framework that would answer the question and deal with the declining gold to plant which is of prime concern to ABG. The two methodologies complement each other because they both deal with human activity systems (Durant-Law, 2005) in that as theory emerges from empirical data rather than from inferences or existing theories from the GT process. SSM on the other hand helps to deal with an unstructured problem that might have reason through the human activity system at play.
Chapter 4: Research Results

4.1 Introduction

The results from data analysis, the GT processes and SSM are summarised in this chapter for which a theoretical code based on the Business Idea model was obtained. The theoretical code and results from the SSM process generated a framework that answers the research question.

4.2 Data Collection

The interviews for the first set of people were analysed and preliminary categories were identified. A second set of interviews was carried out based on the initial categories where the questions were framed around the understanding of the categories in the context of the research problem. The third set of questions was framed as a questionnaire to individuals within the industry who could not be physically interviewed. Their responses assisted in firming up the established categories. This last set of questions was directed to a focus group in the company that deals with reconciliation and, more importantly, the questions included the learning and understanding gained from the memos gathered, during the previous sets of interviews. The number of people interviewed and a sample questionnaire with answers are presented in Appendix F. The memos were notes of recorded ideas that came up during and after the interviews. These were recorded throughout the data collection period and assisted in the categorisation process.

4.3 Grounded Theory

4.3.1 Coding

During data gathering, the transcript after every interview was coded by conceptualising the data to represent a particular concept or key ideas from the interviewee. The transcripts and notes were reworked by picking out key quotes, phrases and examples into single concepts. The selected concepts then directed the sort of questions to be asked at the next stage of interviews. This process was a back and forth exercise but at each stage the data was grouped
and regrouped using the GT Constant Comparison process. Constant comparison involves constantly comparing structurally similar but substantively different concepts or structurally similar but substantively different responses (Soulliere et al, 2001).

Selective coding was carried out to fit the concepts into a more defined category which was then used to guide the theoretical sampling processes. The theoretical sampling in this research was based on literature review selected data in order to reach saturation. Theoretical sampling is a procedure for deciding what groups, subgroups or situations a researcher might turn to next in the data collection process in order to test assumptions about emerging analytic concepts and their properties (Soulliere et al, 2001). Indeed, theoretical sampling involves a process by which emerging concepts from the data point to the next steps of data collection. The goal of theoretical sampling is to choose groups that will help generate as many properties of the categories as possible and that will help relate categories to each other and to their properties.

The literature review was also done by means of a constant comparison process as materials read are compared with data located within the relevant body of knowledge and narrowed down to the categories that had been compiled. The additional data compiled from the literature review allowed saturation to be reached for each of the coded categories and assists in allowing the category to be framed as a variable. The variable gives sense and meaning to the particular concept in the context of the research problem, giving rise to a set of substantive coding. The table below summarises the coding process from preliminary categorisation to substantive codes.
4.3.2 Substantive Coding

Substantive codes conceptualise the empirical substance of the area of research for which the researcher will focus relatively more when discovering codes within the data (Hernandez, 2009). The codes resulting from the GT process, as framed as variables in the context of the research, are as follows:

(i) The importance of **Mine to Mill Reconciliation** in the production Value Chain
(ii) The need for **Team-based Approach** in the Reconciliation process
(iii) The Effectiveness of **Reconciliation Meeting**
(iv) Degree of **knowledge sharing** during meetings
(v) The Level of **Feedback** from the Reconciliation management process

Details of the above variables are presented in Appendix G.

4.3.3 Theoretical Coding

As noted in Chapter 3, Theoretical codes conceptualise how the substantive codes may relate to each other as hypotheses to be integrated into the theory. A series of the coding families
were tried to ascertain which of them would knit together the substantive codes from the data analysis. Similarly other archetypes were evaluated and compared with the substantive codes for which the Business Idea model of Heijden (2001) was chosen as the theoretical model that can be used. The process of selecting a model occurred by means of the constant comparison process where individual codes were compared with the variables of the model. Heijden’s (2001), Business Idea was chosen as the model on which the GT theoretical would be based.

4.3.4 The Business Idea Model

According to Heijden (2001), the Business Idea (BI) is the organisation's mental model of the forces behind its current and future success and it is only when the model is articulated that it can be studied, discussed, modified and improved. This model is built on the principle that value can be created by bringing together a number of factors and competencies. The Business Idea provides a method to consider the future viability of a business proposition in all basic aspects that together make for longer-term success. The variables of the BI model are as presented in Figure 14 below.

Figure 14: The Business Idea model (after Heijden, 2001).
In order to compare the substantive codes with the variables, I used the questions outlined by Heijden for each of the variables in the BI model:

1. **Understanding evolving needs in society.** What are the scarcities in society we focus on? What is the customer value that generates revenue?
2. **The entrepreneurial invention.** What inventive, original insight generated this business opportunity?
3. **The unique activity set.** What are the unique activities that will create the customer value? What are we providing better than anyone else?
4. **The competitive advantage.** What competitive advantage is being exploited? How do competitors do this? What is different?
5. **The results obtained.** How is the financial surplus realised? What aspect of the offering is the price carrier?
6. **The strategic investments** (in assets and learning). How do we sustain and grow our distinctive competencies over time? What specific investments do we make in distinctiveness?
7. **The distinctive competencies.** What resources and competencies that we apply to create our unique activity set are ours alone? What is the system that binds our distinctive resources and competencies together?

### 4.3.5 Isomorphic mapping

Isomorphic mapping is applied in systems theory to gain advanced knowledge of the behaviour of phenomena in our world. It is based on mapping one-on-one variables of a known archetype or model with the substantive codes resulting from the GT process. This helps in arriving at a theory similar to the model it is compared with. The mapping of the Substantive Codes to the variables in the BI model is shown in Table 3. It is worth mentioning that the substantive codes were 5, however to be able to do a one-on-one mapping, two of the key variables recorded in my memos were added to achieve a 100% mapping. These are the Accuracy in financial reporting and the use of the various development programmes that Barrick runs, notable the Compass development programme.
### Table 3: Isomorphic mapping of BI variables to GT substantive codes.

<table>
<thead>
<tr>
<th>Business Idea Model</th>
<th>Variables from the GT Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Understanding the Evolving needs in society</td>
<td>The importance of Mine to Mill Reconciliation in the Production Value chain</td>
</tr>
<tr>
<td>2 Entrepreneurial Invention</td>
<td>The need for Team-based Approach in the Reconciliation process</td>
</tr>
<tr>
<td>3 Unique Activity set</td>
<td>The Effectiveness of Reconciliation Meeting</td>
</tr>
<tr>
<td>4 Competitive Advantage</td>
<td>Degree of knowledge sharing during Reconciliation meetings</td>
</tr>
<tr>
<td>5 Results</td>
<td>The Level of Feedback from the management process</td>
</tr>
<tr>
<td>6 Strategic Investment</td>
<td>Accuracy in Financial Reporting</td>
</tr>
<tr>
<td>7 Distinctive Resources and Competencies</td>
<td>Effective Use of the Compass Development Programme</td>
</tr>
</tbody>
</table>

The rationale behind each of the GT substantive codes mapped onto a BI variable is explained below.

**Understanding the Evolving needs of the Society**
Using the BI model, understanding the evolving needs of the society in this research is mapped to the need to manage reconciliation to improve the mining value chain. For ABG, the current need is to understand the decline in gold grade being delivered to the processing plant. It is an issue that affects the revenue stream of the company, as well as having an impact on the company’s share price.

**Entrepreneurial Invention**
The original insight that generated this business opportunity is the value that reconciliation generates if it is properly managed. One advantage of a well monitored reconciliation is the
improvement it brings into the value chain of a mining industry. It is one of the activities that, if properly managed, would measure its own performance and improvement. This is mapped to the team-based approach variable. It is through a systemic team-based approach that improvement would occur across the entire production chain.

**Unique Activity set**
The unique activity that would create the required improvement to add value to the process is putting in place effective meetings that would bring all the stakeholders together for decisions to be made and promptly identifying any problems and issues that come up in the management process. This variable came up strongly during the data collection process as one of the activities that ABG mines are not using effectively to govern the reconciliation process. Lack of this activity has led to individual groups doing their own monitoring without considering the ‘whole’.

**Competitive Advantage**
The ability to share knowledge internally from lessons learnt through the reconciliation process is the competitive advantage that the organisation would have. Reconciliation in general is a common practice in the industry; however the knowledge gained through a team-based approach makes a difference. The associated high level of interaction, and a holistic approach, would result in the breaking down of silos mentalities and negative competitions within ABG. The difference it would make is that during structured and well-attended meetings, key stakeholders – especially from the corporate office who attend these – could serve as mentors to the young members of the team present at the meetings.

**Results**
The results to be obtained would be the prompt identification of errors that would come through the feedback processes. The errors in estimation and the reasons for any variations would be promptly fed to the estimation team and ratified. Results would be purely based on the level of feedback from the management process to the people on the ‘shop floor’ and how it improves in the monitoring of grade from the mining face to the processing plant.
Strategic Investment

Effective monitoring of reconciliation could help the company demonstrate that not only has it created a Resource or Reserve estimate but that it is also monitoring the mining of that material, diligently comparing actual performance with original estimates and, where necessary, modifying and improving the estimation methodologies to ensure more accurate prediction. This form of strategic investment would also set the company up to ensure that it delivers on its promise to the shareholders. The finance team, who would be attending the reconciliation meetings, would gain an understanding of the reconciliation process that would assist them in their reporting role.

Distinctive Resources and Competencies

The Compass development programme is Barrick’s own developmental programme designed to train its graduates entering the industry. I was personally involved in drafting the Mining Geology section of the Compass development programme, developed by Barrick. The programme consists of two main complementary dimensions: knowledge and experience. Experience is obtained through the interaction that the student gains during the programme, which is a prelude for the graduate geologists’ understanding of the importance of team-based problem solving in the mining industry. Knowledge involves information, hard data and technical instruction programmes coupled with sophisticated collaboration and information sharing tools that enable each individual to balance field work with structured knowledge, technologies, models and methods that are essential to the mining industry.

The variables as presented above would form the basis for which a successful governance process can be put in place for the company in order to improve value creation in the mine operations. The dynamics of the variables as mapped onto the BI model creates a framework that would serve as the backbone for the management of the reconciliation process. This is a holistic framework for which each member in the production chain, as well as those within the service group (e.g. Finance), would have to be part to ensure the success of the model. Figure 15 is the framework (termed Theoretical code in GT) that is proposed for the improvement of the reconciliation management process.
4.4 Reconciliation Meetings

The GT result has set the base towards the answering of the research question, for which the improvement framework is such that the key activity that would drive the reconciliation process is through an effective reconciliation meeting. However, during the interviews, it came out strongly that these sorts of meetings have not been held properly and concern regarding our inability to set up the process to effectively manage the entire reconciliation process as a team was raised. The question raised by most interviewees was why we are not putting in place a scheduled meeting programme and inviting the concerned professionals to discuss reconciliation issues. Though this was clearly an issue, most interviewees were unsure why the meetings are not carried and even when they are carried, why they are so poorly attended. It is worth mentioning that most of the interviewees had a different perspective of why the meetings were not held effectively and mostly their views were related to how they would want the reconciliation process to be managed. Most of them believe reconciliation is the responsibility of the geologists and that they should always find a way to deal with any variances that arise. Their perspective to the underlying concern is different. Therefore I decided to go through the SSM process as outlined in the methodology section. A significant feature of SSM is that it can be used as an approach to stimulate debate and capture the perceived visions of participants and can be used to facilitate effective change.
and improved work practices by allowing the exploitation of individual and socially constructed knowledge and experience (Finegan, 2010). The results are presented below.

4.5 Results from SSM

4.5.1 – The Problem Situation (Step 1)

The problem situation is that each of the key stakeholders is not in agreement as to how the reconciliation meetings are to be carried out. The disagreement among stakeholders is a reflection of the different emphasis they place on the various causal factors. It is an unstructured situation that needs to be dealt with.

4.5.2 Rich Picture (Step 2)

The rich picture of the problem situation is presented in Figure 16. It is important to note that the picture depicts my views of the problem, based on understanding of views expressed by stakeholders and those interviewed for this research.

Figure 16: Rich picture of the reconciliation meeting issues.
## 4.5.3 CATWOE of stakeholders (Step 3)

The various key stakeholders in the management of the reconciliation process as presented in the rich picture are geology, mine planning, metallurgy and finance. The CATWOE for each of the stakeholders is presented in Table 4.

### Table 4: CATWOE of stakeholders.

<table>
<thead>
<tr>
<th></th>
<th>Geology</th>
<th>Mine Planning</th>
<th>Metallurgy</th>
<th>Finance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Customers</strong></td>
<td>Mine Planning, Metallurgy</td>
<td>Metallurgy, Geology &amp; Finance</td>
<td>Finance, Senior Management</td>
<td>Senior Management and Shareholders</td>
</tr>
<tr>
<td><strong>Actors</strong></td>
<td>Resource Geologist and Grade control Geologist</td>
<td>Long term and short term planning engineers</td>
<td>Plant Metallurgist and Process Engineers</td>
<td>Financial Reporting Accountants</td>
</tr>
<tr>
<td><strong>Transformation</strong></td>
<td>Geological interpretation and estimation of mineable tons and grades</td>
<td>Optimisation and scheduling of reserves</td>
<td>Processing of gold bearing material to extract gold</td>
<td>Reporting of financial statement of the company</td>
</tr>
<tr>
<td><strong>Weltanschauung</strong></td>
<td>Evaluation of mineral deposit for mining</td>
<td>Evaluation of reserves for mining</td>
<td>Extraction of gold to generate revenue for the company and margins for the shareholder</td>
<td>Present the financial situation of the company</td>
</tr>
<tr>
<td><strong>Owners</strong></td>
<td>Shareholders and Senior management of ABG</td>
<td>Shareholders and Senior management of ABG</td>
<td>Shareholders and Senior management of ABG</td>
<td>Shareholders and Senior management of ABG</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td>Complying to JORC definition and policies of the government</td>
<td>Complying to JORC definition and policies of the government</td>
<td>Complying with environmental standard and policies of government on pollution and contamination</td>
<td>Compile to International Financial Reporting Standards, SOX and LSE regulations</td>
</tr>
</tbody>
</table>
4.5.4 Root Definition of Stakeholders (Step 3)

The root definitions for the stakeholders are presented below:

**Geology** - The role of the geologists is to explore and evaluate the mineral resource potential for ABG-owned mines using the right estimation methodologies in accordance with industry reporting standards. This is to ensure that quality mineable ounces are produced at a profit to generate the desired economic returns to the ABG shareholders and all other stakeholders.

**Mine Planning** - The evaluation of economic mineable reserves using the right prevailing economic parameters based on standard reporting guidelines. Plan mining schedules and mine according to the geological dimensions of the orebody to reduce ore loss or dilution and thereby generate the desired economic returns to ABG shareholders and all other stakeholders.

**Metallurgy** - The role of the metallurgist is to process, extract and recover gold at a profit from gold-bearing material using environmentally friendly reagents. Presents a transparent metallurgical accounting for material processed through the processing plant in order for the company to present an accurate financial report.

**Finance** - To present an accurate financial state of the company including its mineral assets (mined and un-mined) using gold production and reconciliation results as per the stock exchange and industry reporting requirements. This is to ensure that the company is properly valued at the stock market and the right margins are presented to the shareholder and other stakeholders.
4.5.5 Conceptual Models (Step 4)

Conceptual models are the diagrammatic activity representations of the root definitions. The conceptual models of the various stakeholders are presented below.

![Conceptual Models Diagram]

**Figure 17: Conceptual models for key stakeholders in Mine to Mill reconciliation.**

4.5.6 Evaluating the E’s

Based on the root definition and conceptual models, the evaluation of the stakeholder activities were carried out in terms of:

1. E1: Efficacy (establishing whether the system works in its own terms)
2. E2: Efficiency (establishing whether the system works with minimum resources)
3. E2: Effectiveness (establishing whether the system meets longer term aims)

For all stakeholders the following was observed:

E1 – The systems cannot work on their own as they need each other’s input for some of their activities, as shown in the conceptual models.

E2 – The system has enough resources to work with. However the lack of common purpose from the teams is not helping in achieving headway in the reconciliation process.
E3 – Not all systems have been participating in the reconciliation meetings. Attendance and participation have been very poor.

4.5.7 Model Comparisons (Step 5)

Comparison is made between the main activities where there are significant differences between the conceptual model (step 4) against the activities presented in step 1 and 2.

Table 5: Models comparison between system thinking and real world.

<table>
<thead>
<tr>
<th></th>
<th>System Thinking (step 4)</th>
<th>Real World (step 1 &amp; 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geology</strong></td>
<td>Validate geology database and modelling parameters</td>
<td>The validation process mostly occurs during the exploration stages.</td>
</tr>
<tr>
<td></td>
<td>Demarcate mining block outlines</td>
<td>The demarcations can contain some dilutions</td>
</tr>
<tr>
<td></td>
<td>Presentation of Mine to Mill Reconciliation figures at Reconciliation meetings</td>
<td>Meetings are not well attended and the geologists do not always explain the variance between the predicted and actual</td>
</tr>
<tr>
<td><strong>Mine Planning</strong></td>
<td>Drill and blast benches based on mining schedule</td>
<td>Drill and blast is one source of dilution in the mining stages</td>
</tr>
<tr>
<td></td>
<td>Mine reconciliation and present at reconciliation meetings</td>
<td>Mine planning engineers leave the reconciliation process to the geologists</td>
</tr>
<tr>
<td><strong>Metallurgy</strong></td>
<td>Back Calculate tons and grade based on bullion</td>
<td>The grades calculated does not take into consideration any inefficiencies in the processing route</td>
</tr>
<tr>
<td></td>
<td>Mill Reconciliation</td>
<td>The Metallurgical accounting process is sometimes difficult to understand</td>
</tr>
<tr>
<td><strong>Finance</strong></td>
<td>Calculate assets based on declared Reserves and Stockpile figures</td>
<td>The accountants take these figures as the truth from the operations team.</td>
</tr>
<tr>
<td></td>
<td>Reconciliation meeting</td>
<td>The finance team do not sit in the reconciliation meetings.</td>
</tr>
</tbody>
</table>
4.5.8 Feasible Changes (Step 6)

Each member of the operational team, including finance, should be part of an integrated management team listed in the rich picture (Step 2). The team must be formed with the full blessing of the senior management team. This team, which could be called the Mineral Resource Audit team, should be given a list of measurable criteria and well-defined objectives, as well as the authority, to carry out random and/or routine audit on all the measurable tasks. In addition, the team should be given the opportunity to create awareness of all the factors that contribute to reducing risk in grade control and reconciliation (people, money, time, information and skill) to maximise company profit.

4.5.9 Action to improve the Situation (Step 7)

The action is to set the reconciliation meetings that will get people talking about the impact of the declining grade on the company revenue. It is only during such meetings that people will exchange ideas and find solutions to problems. However, this can only be set up with the active involvement of management in the process and ensuring that meetings are held regularly.

The two key variables to improve the meetings, is setting up effective communication structures and obtaining management involvement through shared management practices to ensure that the feedback process is carried through to the various levels of the production chain. Communication in business teams is essential for effective teamwork, technical excellence and customer responsiveness (Connolly, 1996). Tarricone and Luca (2002) also believe that business success specifically refers to profit-generation, which does not simply refer to employees generating cash flow and contacts for the business but also includes the ability of employees to create and maintain positive working relationships. The essence of a good working relationship would mean that each head of department would fully participate in and – ensure that his or her team fully integrates into – the bigger site team. This would in turn increase the level of supervision and control of dilution, ore loss and good process recovery.
The inclusion of communication and shared management practices to the GT process framework results in a complete improvement framework that is holistic and would answer the research question. This creates four distinct reinforced management loops which would drive to ensure an effective running of reconciliation meetings. The dynamics of these four loops is represented in the CLD of Figure 18 and the links for each of the loops is presented in Table 6.

![Diagram](Image)

**Figure 18: Framework to improve reconciliation management.**

The Effectiveness of Reconciliation meeting occurs in all the loops, making it a leverage point that controls the effectiveness of the entire framework presented to deal with the concern. It is crucial that the meeting leadership ensures the successful running of the meeting as well as implementing any action from the meetings.
Table 6: Dynamic loops within the improvement frameworks.

<table>
<thead>
<tr>
<th>Loop ID</th>
<th>Variables linkage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ro</td>
<td>The Effectiveness of Reconciliation Meeting → Degree of knowledge sharing during meetings → The Level of Feedback from the Reconciliation management process → The accuracy of financial reporting → Effective use of the Barrick's Developmental Programmes → The Effectiveness of Reconciliation Meeting</td>
</tr>
<tr>
<td>Ra</td>
<td>The Effectiveness of Reconciliation Meeting → Degree of knowledge sharing during meetings → The Level of Shared Management practices → The level of Communication → The Effectiveness of Reconciliation Meeting</td>
</tr>
<tr>
<td>Rb</td>
<td>The Effectiveness of Reconciliation Meeting → Degree of knowledge sharing during meetings → The Level of Shared Management practices → The level of Communication → Team-based Approach towards the Reconciliation process → The Effectiveness of Reconciliation Meeting</td>
</tr>
<tr>
<td>Rc</td>
<td>The Effectiveness of Reconciliation Meeting → Degree of knowledge sharing during meetings → The Level of Shared Management practices → The Level of Feedback from the Reconciliation management process → The accuracy of financial reporting → Effective use of the Barrick's Developmental Programmes → The Effectiveness of Reconciliation Meeting</td>
</tr>
</tbody>
</table>

4.6 The underlying principles for improvement

The central key to the management of reconciliation is carrying out an effective reconciliation meeting where all the key stakeholders and professionals involved in the production chain meet to discuss the variance between the estimated, planned and achieved in a holistic manner. This would lead to a stable pattern of collective activity through which the organisation systematically generates and modifies its operating routines in pursuit of improved effectiveness (Zollo and Winter, 2002). This would also engage the team to take collective action leading to greater participation, collaboration and interaction. In this case each person would strive to ensure that the strategy is implemented and carried through. The underlying principles of the four distinct loops are explained below.
4.6.1 Governance of Reconciliation process

This loop (Figure 19) is made up of The Effectiveness of Reconciliation Meeting → Degree of knowledge sharing during meetings→ The Level of Feedback from the Reconciliation management process → The accuracy of financial reporting → Effective use of the Barrick’s Developmental Programmes → The Effectiveness of Reconciliation Meeting.

The claim here is that an effective reconciliation meeting would lead to a greater governance of the reconciliation management process that would bring improvement in the production processes, as well as in the monitoring and estimation of the ‘true quality’ of the material delivered to the processing plant. As the ABG Corporate Geology Manager, I have tried instituting a monthly reconciliation management meeting at the mines. Though the meetings have not been held regularly, the ones that were held had an impact on the understanding of issues relating to production performance. At one such meeting, the team recommended the involvement of all the stakeholders in the process in order to achieve a better understanding of all the issues at stake.

Such meetings would increase the level of knowledge sharing especially among the key stakeholders in the reconciliation processes if effectively held. In an industry where people move around from one company to another with ease and frequency, knowledge is considered a strategic asset that should be protected (Lopez, 2005). The dynamics of
knowledge sharing creates a pool of strategic stock in the organisation; creating a form of dynamic capability that is the firm’s ability to integrate, build and reconfigure internal and external competencies to address the rapidly changing environments (Teece et al, 1997). In this sense, knowledge is to be considered a strategic asset and a source of sustainable competitive advantage for the organisation.

Recently the Barrick Corporate Technical Services Vice President, noted that the reorganisation of technical services from focusing only on technical services to an integrated team that incorporates related functions such as Business Improvement, Supply Chain and other services under one umbrella has allowed the section to take a cross-functional approach that has provided integrated solutions all the way along the value chain (Barrick Central, 2010). Similarly bringing all the professionals associated with the production chain, and including other services such as Human Resources, Finance, Administration and IT, would create the required improvement to increase the value gained from the reconciliation process. This is also one of the key areas where knowledge would be shared and utilised in the company.

The loop also includes improved feedback resulting from good and effectively run reconciliation meetings. Feedback is mothers’ milk for improvement within an organisation (Scholtes, 1998). The action items from the meetings would have to be feedback to the operations team for them to action it to bring about any form of improvement that the recommendations address. It is important to note that most of these reconciliation meetings would be attended by people who are heads of department. However the action would be carried out from supervisor level and therefore any decision would have to be driven down by the supervisors.

Effective feedback would assist the financial reporting team to accurately report on reductions or increases in material at the stockpile. This information would only be available to the finance team either through feedback from the meetings or if they are involved in the meetings. There are times that reconciliation monitoring discovers that the material on the ROM pad is either lower than or higher than the values in the accountant’s book. Letting the accountant know of such discrepancies is important for the reporting of the right assets for the company. According to Morley and Thompson (2006), reconciliation plays an increasingly important role in a statutory context as a result of industry codes such as the
Australasian Code for Reporting of Mineral Resources and Ore Reserves (the JORC Code), the South African Code for Reporting of Mineral Resources and Mineral Reserves (SAMREC), the Canadian National Instrument 43-101 and legislative requirements such as the Sarbanes-Oxley Act (SOX). The purpose statement of SOX summarises the intent of these codes and legislation as to protect investors by improving the accuracy and reliability of corporate disclosure made pursuant to securities laws and for other purposes. The outcome of reconciliation meetings is thus important to the financial team. This is also one of the reasons that the team-based approach with the inclusion of the financial team in the management meeting process is important.

The Compass programme is a Barrick initiative to give new graduates entering the industry the necessary skills, knowledge and tools they need to become the technical experts and business leaders of the future. The programme is aimed at developing the talent that will be key players at Barrick in future. By offering its employees programmes that develop their competencies, Barrick would have the distinctive competencies in the industry (Compass handbook, 2009). These graduates are the future managers of the company and once they are in the habit of working in teams, reconciliation management will become part of their work activities.

This loop would effectively work if the entire team is ‘on board’ to ensure the successful running of the reconciliation meeting which serves as governance for the processes. Though this is a framework that will bring improvement in the management of the process, it is fully dependent on the meeting leadership, which must ensure that everything is in place to make the running and the outcomes of the meeting effective. It is important to note that in the case where any of the variables changes to the negative, it would affect the whole loop and may reverse it from being a positive reinforced loop to either a negative reinforced loop or a balanced loop.

**4.6.2 Management Involvement in Reconciliation Management**

In order to keep the Ro loop in a constantly positive loop, it is important that the reinforce loop of Ra (Figure 20) is maintained to ensure that it is working properly. A shared
management practice is a connector that needs to be maintained constantly to ensure that communication flow through the management process is of a high order and is there to keep the governance process in check and order.

According to Sussland (2003) shared management provides a compatible and efficient way of working throughout the organisation and in order to eliminate cracks in the process-architecture, it is important to connect all management processes in a company-wide framework. The senior management team as well as the middle management (heads of department and senior supervisors) would have to serve as the key connectors in ensuring that the process is followed in order to implement any improvement strategies that come from the reconciliation meetings.

The connection between shared management practices and effective reconciliation meetings is the high level of communication needed. This is the case where site management is involved in the reconciliation process. The communication being proposed as a link is the face-to-face type communication with the team as this is one medium in which effective dialogue and interaction occurs. The impact of a face-to-face medium may be due to its immediacy but the interactive potential of it, if realised, is what works.

The two-way give and take encourages involvement in the process. It also clarifies ambiguities, and increases the probability that the sender and the receiver are connecting
appropriately. It is the best way in which feedback can be used to correct deficiencies immediately in the communication process (Klein, 1996). In this regard, the meeting would be held in an atmosphere where any difference in the estimation process, mining or the metallurgical accounting processes are sorted out during the meeting and improvement strategies are carried out.

4.6.3 The significance of a Team-based Approach

The Mine to Mill process involves at least three key professionals – Geologist, Mining engineer and the metallurgist. However from Resource estimation to bullion, there are other professionals that come across the gold-bearing material before the final gold is extracted from it. The survey crew, maintenance team, mining and geology technicians are all involved, as well as the IT, finance and the human resources professionals that come across the production chain. Therefore to effectively manage the process, it is important to bring representatives of the various teams together to discuss any variances and issues within the reconciliation processes. According to Rabey (2003), a team is a group of people with either mixed or complementary skills working together for an agreed purpose. Performance can be enhanced and obstacles overcome by the synergy of teamwork. In the industry and more especially in Tanzania where there is a large force of expatriates working with the Tanzanians, building a strong team is important as each of the expatriates comes with their own understanding and experience which has to be tapped to improve on the reconciliation process.

Communication (Figure 21), which needs to be set up to encourage the involvement of the teams, is the link between shared management practices and the team. A strong team is always built on good communication as this will lead to clarity of roles, information flow between the members and, provided there are good leadership skills, team members will respect each other irrespective of knowledge, gender or colour.
According to Ingram (1996), teamwork is a disciplined and focused way of working which may be described by the following characteristics:

**Relationships** - Teams work through face-to-face relationships between people in specifically formed groups. There is a link between the quality of relationships and the team’s performance.

**Social** - People like to congregate in groups, and teams represent units of social interaction and potential sources of satisfaction at work.

**Purposive** - Team members interact with one another for the purpose of performing to attain a common goal. A common source of team failure is that team members interpret the task in different ways, so that outcomes or methods are not clearly apparent to the whole team.

**Culture** - Effective groups, including teams, generate their own rules, procedures and culture. The term group think describes those shared values and opinions that can be a source of innovation or may act as a barrier to organisational change.

This is the sort of team that is required in the team-based reconciliation management process.
4.6.4 The other side of Shared Management Practices

As explained above the second link to management involvement through shared management practices is to ensure that the feedback process (Figure 22) in the reconciliation management is of the high order. It is through the feedback process that action items on the agenda and minutes of the meeting can be sent through to the appropriate owners to action the items. In this scenario, the role that senior management plays is to set the goals and objectives which align the group with the company’s values and missions.

Figure 22: Dynamics of a shared management practices in reconciliation.
Chapter 5: Conclusion and Evaluation

The GT and SSM processes followed have led to the identification of a framework that will assist in redesigning the reconciliation management process transforming it into team-based approach governed by means of effective reconciliation meetings. This chapter draws on the conclusion and evaluation of the research work by analysing the implication and significance, relevance, utility and validity of the research and results based on the current ABG’s situation and concern regarding declining gold grade. It also evaluates the ethical implications for putting in place a sound and effective reconciliation management process. The ethical evaluation is carried out on key stakeholders of the ABG mines in Tanzania.

5.1 Implication and Significance of the Research

During the last three years, ABG has consistently been reporting lower production than planned and at a high cost. This is mostly due to the fact that planned grade required to be delivered to the processing plant is lower than the final achieved grade. The process of comparing the planned grade to the final grade is reconciliation. However the management of the process is done in parts in that each of the various groups manage their processes separately. This has not been optimal in the management of the entire process. This research was set up to redesign the process through a systemic approach for which the main research question was;

**How can a systemic approach improve the Mine to Mill Reconciliation process?**

The question that may be asked is why the need for a systemic approach can be answered by the fact that, the entire production chain, which starts with an estimate of the grade goes through several levels of estimation processes carried out by geologists, surveyors, mining planning engineers before the actual value of the material is determined by the metallurgist. Therefore in order to improve the management process there is the need for a systemic approach for which of the groups involved in the production would be part of the process. It is by means of a systemic approach that ideas and concepts from the various disciplines could be drawn from their different strengths.
The answer to the question is that there is the need to set up a team-based approach to manage the entire reconciliation process by means of well organised and effective meetings. The concern of ABG is to deliver on its promise to shareholders by ensuring that planned production is achieved. In order for this to be accomplished, the collective participation of all the groups within the production chain is needed. The holistic approach by means of the reconciliation meeting would also assist in ensuring that any deficiencies along the production chain would be picked up and addressed as quickly as possible. This answers the question and deals with the declining gold grade to the processing plant.

The reason for picking the reconciliation management process as a key research area is that it is through which a mining company would be able to understand the ‘true’ value or the quality of the deposit being mined.

For example at the Buzwagi mine, the grade that, the geologists and mining engineers (both planning and production) delivered from the pit to the crusher is far higher than reported by the mill team. Each group believes they have done all the necessary checks and are sure their numbers are right. During 2010, the calculated difference between the ore reserve grade and the mine grade registered a drop of 13%. In addition, the mill is reporting a further 7% lower grade than what the mine is said to be delivering. During the early part of 2010, all the discipline heads on the mine were called to a meeting to address these shortfalls but not all the invited participants attended the meeting. Those who absented themselves claimed they had provided the ‘right’ figures and that it was the geologists’ call to solve any grade discrepancy issues. With this attitude, it was not surprising to note that at the end of the 2010 reporting year, the mine produced only about 60% of its targeted production. In order to find out the true value of the grade which forms the basis of all the financial models and assumptions, there is the need to bring everybody together through a meeting process.

The significance of this research has given me the necessary tools to run these meetings from a corporate perspective. During the interview process, most of these key people were interviewed and agreed to the need for well-organised meetings to deal with the situation. The research has also highlighted the importance of including other disciplines that are not directly related to production. For example, it became clear that the finance team should be involved in the reconciliation management process as they are the custodians of the financial
report which is based on production statistics. Their presence would foster an understanding of the reasons behind the variances reported by the operations team. It would allow for a better understanding of the reports they present.

Resulting from the fact that although reconciliation meeting was carried out, it generally was not well attended. The next question I had to ask in order to give a greater utility to this research was;

**What should senior management do to ensure the process is carried out properly?**

The answer to this question came up during the SSM process where the concept of shared management practices was identified. It is only shared practices that allow an effective reconciliation meeting to be carried out. Setting up communication structures and getting management involvement would ensure that the feedback process is carried through to the various levels of the production chain. With reference to Heijden’s (2001) Business Idea model, a business that wants to survive needs to develop a virtuous (positive feedback) loop that feeds back some of the benefits of its unique performance into investments that maintain distinctive resources and competencies, allowing the firm to continue to operate a unique activity set from which competitive advantage is derived. This is what is expected of the senior management team that would have to ensure that the process is set up to succeed. It would have to be actively involved or given the necessary support for this framework to succeed. The involvement of the General Managers as well as the Corporate Technical leads would greatly ensure that the meetings are run effectively and any improvement strategies that come out of such meetings are implemented.

Knowledge sharing would also lead to the effective feedback process that would assist both the technical and production teams to effect any changes and improvements that come out of the meetings. In a team-based approach where finance teams are represented, it would give them a better understanding and equip them to accurately disclose the right information, with respect to the asset base of the company, to investors and analysts. One of the core variables in the answer is the developmental programmes that are run at Barrick – the Compass programme, and the UCT GSB management development programmes. These two developmental programmes create distinctive competencies in the workforce of the organisation. Once fully utilised, these programmes would enable the graduates and the
workforce to understand the value structure of the company and the importance of a systems thinking approach in solving problems.

It is through the reconciliation management meeting that the Senior Leadership Team of ABG would be well informed of issues causing any decline in productivity. This would position them to give guidance that is within acceptable limits. The meetings would also reduce the level of complexity that both the GM’s and the SLT have to deal with as they would be given feedback from the meetings in respect of any improvement strategies.

5.2 Evaluation of the Research work

This research has been evaluated in terms of the process followed that establishes the relevance, utility, validity and ethics.

5.2.1 Relevance of the Research

Mine to Mill Reconciliation is the process through which the final and ‘true’ value, quality and quantity of a gold deposit, can be evaluated from the initial estimates by the geologist to the end of the process when bullion is achieved from the treatment plant. From the geologist’s initial estimate to bullion, the piece of gold-bearing rock would have passed through the hands of so many professionals in the mining production chain all of whom, in one way or the other re-evaluated the value of gold in that piece of gold bearing rock. However, the true grade of the material is ‘somehow’ not known until the metallurgist estimates the grade based on the gold at hand. Nonetheless, this value might have been wrongly estimated from the geological model or the mining engineer might have applied the wrong economic and modifying factors during the optimisation and mining processes. The grade control geologists might also have wrongly categorised the material before it is dug out from the pit or stope. Waste material could be added to the gold-bearing rock to increase volumes or the concentrations of reagents in the plant may have been wrongly applied to the material. Comparing the estimated grade of the ore, by the geologist, to that of the planning engineer and to the Mill figures is a difficult task to perform in isolation or in parts. It is
therefore necessary to bring all the stakeholders together to, holistically, work out the reasons for any variances.

The management of reconciliation should not be done at various monitoring points in isolation. Currently the geologists look at the variance between the initial estimates and the value given by the process team and do not involve them in any form of discussions to find out the reasons for the variances. The Corporate Technical Services group have on numerous occasions tried to get the teams together but this has not been effective. The site senior management team and SLT of ABG would have to ‘come to the table’ to assist in driving these all-important meetings. The issues affecting the delivery of lower grade to the plant cannot only be attributed to inaccurate estimation or mining waste. It could also be due to ‘soft issues’ such as poor communication, lack of interaction, lack of supervision and the dynamism of team interaction among the various production teams from geology, survey, mining and metallurgy.

ABG is a new company that has been established on the basis that it would be better positioned to generate shareholder value by operating and competing with the major players in Africa. Achieving its targets, therefore, is of prime importance. The shareholder would like to see returns on his/her investment for which one of the primary contributing parameters is the grade delivered to the plant. This affects processing cost and the revenue stream in that lower than expected grade to the plant means treating the waste added while there is an additional cost of mining the waste material to the plant.

The research has established the fact that proper reconciliation management would increase the performance of the teams as they become more aware of the issues at stake and would work out the necessary improvements to ensure that operational targets are met. This could be achieved if the answer as obtained from the GT and SMM processes is followed. The management and or governance of reconciliation would lead to improvement in the estimation and evaluation of the company assets as well as providing direction regarding the improvement of key indicators of reconciliation.
5.2.2 Utility of the Research

Utility is the link from C→ Q→ A in the SCQARiE framework. It has been established that the declining plant feed grade is not due to the inefficiencies of one team or group but it is the results of a dynamic interplay between the teams. This complex situation calls for a system that evaluates at the problem from a systemic point of view in order to find a solution to it.

The question posed for the research is;

**How can a systemic approach improve the Mine to Mill Reconciliation process?**

While this question seeks to understand what improvement a systemic approach, based on involving all teams within the production chain, bring to the reconciliation management processes, the second question below which was asked later in the research period requires the senior management team to be actively involved in ensuring that the first answer to the first question is implemented.

**What should senior management do to ensure the process is carried out properly?**

The grade of the material is one of the important parameters in the industry. Watchorn (2001) notes that an operation’s sensitivity to grade is much greater than to any other factor whiles Kaesehagen (2001) believes that “Grade is king” should be the planning engineer’s motto. Grade is by far the most important variable in mine planning. Therefore, this current scenario in which grade is declining and has resulted in the company not achieving its target, is of great concern to the shareholders, investors and the senior leadership team, and a solution to the problem must be found. The question once answered would assist in dealing with the concern.

The systemic approach that was followed in answering the question identified a team-based approach as key in managing mine to mill reconciliation, for which an effective reconciliation meeting should be setup to develop a proactive and continuous improvement approach. Also eliminating any risks or factors that affect the revenue stream, as a result of poor reconciliation at the various monitoring points is of prime importance to the company. The reconciliation meetings would serve to increase the knowledge base of the reconciliation process.
management process as well as increase the level to which shared management practices, that seek to provide an efficient way of working, would raise organisational effectiveness.

The GT and SSM processes identified the fact that lack of coherent interaction within teams result in the failure to manage the process. There was a strong need to set up an effective reconciliation meeting system which is the leverage point that holds the management process in place. From the GT process, it was noted that the failure to manage reconciliation from a team-based approach is the underlying cause of not understanding the reason why lower than expected grade is being sent to the mill. The need to increase communication and teamwork is key in ensuring that the process is managed effectively. The GT process also noted the importance of Barrick’s Compass development and the Management development programmes as core competencies that would assist in driving the management of reconciliation. These competencies when used to assess reconciliation issues holistically, during reconciliation meetings, would create a sense of knowledge sharing which would create the necessary strategic advantage within the industry.

Putting in place an effective reconciliation meeting to govern the reconciliation process would inevitably permit the development of proactive and continuous improvement approach to solutions with the attendant reduction or elimination of many hidden costs and risks, in the production chain, caused by poor reconciliation practices.

5.2.3 Validity of the Research

The validity of the research examines the argument behind the variables within the answer, how they are linked up and the argument behind the connections. The trustworthiness in terms of credibility, confirmability, dependability and transferability of the research is also examined.

The answer was arrived at through a ‘pain staking’ process of interviewing and writing memos throughout the first five weeks of the research. It was the ‘back and forth’ nature of the GT processes from which a substantive code was achieved. It was also important that I avoided the use of my own perspectives in putting down the responses of the interviewees.
Though I had my own perspective of the issues, the insights gained from some of the interviewees were of great benefit to my understanding of the problem. The most significant of these insights came from the ‘mini’ literature review to reach saturation of the various codes that had been identified. It allowed me to further understand some of the memos I had put together during the interview. It also increased the level of perspectives that was brought into the processes. The vigour of the GT process also helps in the analysis of the SSM processes. The combination of the GT, SSM and the memos helped in identifying the connections and dynamics of the various variables which were put together to arrive at the answers (Figure 23) to the questions which stipulate that an effective meeting activity would serve as a leverage point to deal with the concern within the situation. Effective meeting is a leverage point in the framework because it is only in an effective reconciliation meeting that all the improvements strategies and objectives can be collectively harnessed for implementation.

Figure 23: Effective meeting as a leverage activity in reconciliation management

Credibility
The research was carried out based on the CR philosophy as well as the GT and SSM processes which is a direct result of actual interviews conducted during the research period
together with the memoing process from my interactions with ABG Tanzanian mine employees. The process followed in arriving at the answer is based on appropriate system-thinking methodologies. It is also worth mentioning that I have a strong understanding of the issues at stake, having worked in the gold mining industry continuously for the past 17 years. I have been involved in geological resource modelling, grade control modelling and reconciliation. I therefore have a strong geological and mining geology understanding of the industry. I also have a strong belief that if the answers to the research questions are applied, it would improve the estimation, control and processing of the material thus achieving targets for the company.

**Confirmability**

The processes followed in the GT process have been documented as well as the SSM process. These processes are based on credible literature as well as lecture notes from the EMBA programme and are supported by plausible literature reviews which are outlined in the reference section of this report. The processes followed in the research process are based on academic outlines from the EMBA programme including the SCQARiE format guidelines presented during the programme. The information and references presented in this report are sufficient for any third party to follow and make use of the processes.

**Dependability**

The processes to arrive at an answer that addresses the research question and deals with the research problem (concern) have been followed diligently. This shows that effective reconciliation meeting is a leverage point that would hold the framework together and the slightest change to the effectiveness of the meetings would have an impact on the results achieved from the reconciliation management processes. The connections between the variables in the causal loop diagrams as presented in the report have been carefully outlined.

**Transferability**

The management of mine to mill reconciliation within the mining industry is one of the key continuous improvement functions. Therefore any framework that seeks to give a better understanding and processes that would improve the reconciliation management would be highly accepted in the industry. Thus the findings and results from this research are easily transferable to any mining house. There are, however, certain competencies that would have to be adopted if it is to be transferred to other Barrick global sites.
5.2.4 Ethical Implication

The first core value of Barrick is to ‘Behave like an Owner’ for which the company states that “We accept accountability for our actions and results. We treat the Company’s assets as our own. We are entrepreneurial and look for opportunities to grow our business. We act with integrity, operating within the letter and spirit of the law and Barrick’s Code of Business Conduct and Ethics”. The Company’s Code of Business Conduct and Ethics embodies the commitment of Barrick Gold Corporation and its subsidiaries to conduct business in accordance with all applicable laws, rules and regulations and the highest ethical standards throughout our worldwide organisation. Key and Popkin (1998) noted that using ethical considerations in strategic decision-making will result in the development of the most effective short-term and long-term strategies. Specifically, ethical criteria must be included as part of the strategic process in before-profit decisions rather than after-profit decisions in order to maximise corporate profits and improve strategy development and implementation. It is ethical to increase profit for the investors and shareholders rather than loosing revenue through the delivery of ‘waste to the plant’ and mining waste at a cost. Therefore integrating ethics into a management process is not only the right thing but also the profitable thing to do.

The ethical evaluation of the proposal is carried out using Velasquez’s four question models which enquires into the utility, rights, justice and caring involved in any particular moral judgment. The ethical implication for each of the stakeholders is presented in the Table 6 below. It is worth mentioning here that the key stakeholders in ensuring that the reconciliation management process is run effectively are;

1. The ABG Workforce
2. Senior management at ABG
3. The community within which the company operates and the government of the country
4. Shareholders and Investors
<table>
<thead>
<tr>
<th>Key Stakeholders</th>
<th>Utilitarianism</th>
<th>Rights &amp; Duties</th>
<th>Justice</th>
<th>Caring</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ABG workforce</td>
<td>‘Does the action, as far as possible, maximise social benefits and minimise social injustices?’</td>
<td>‘Is the action consistent with the moral rights of those whom it will affect?’</td>
<td>‘Will the action lead to a just distribution of benefits and burdens?’</td>
<td>‘Does the action exhibit appropriate care for the wellbeing of those who are closely related to or dependent on oneself?’</td>
</tr>
<tr>
<td></td>
<td>Achieving target would result in paying bonus to the workforce. The increase would increase money in circulation for the social benefits for even those not directly related to the mines.</td>
<td>The act of monitoring and managing reconciliation would not affect the moral rights of the workforce. The workforce rather has the obligation to ensure that production target is achieved.</td>
<td>Effective reconciliation would lead to the improvement in production for which the workforce would benefit since the company would continue to make their jobs sustainable.</td>
<td>The family of the workforce would be happy to see the mine worker continuing to work instead of being redundant. The worker would be able to carter for his family.</td>
</tr>
<tr>
<td>Senior management at ABG</td>
<td>‘Does the action, as far as possible, maximise social benefits and minimise social injustices?’</td>
<td>‘Is the action consistent with the moral rights of those whom it will affect?’</td>
<td>‘Will the action lead to a just distribution of benefits and burdens?’</td>
<td>‘Does the action exhibit appropriate care for the wellbeing of those who are closely related to or dependent on oneself?’</td>
</tr>
<tr>
<td></td>
<td>To Senior management , achieving targets also means getting high bonus and gratification for their roles and achieving the needed margins for the shareholder.</td>
<td>The action of ensuring that reconciliation is managed properly is the right thing to do for which the senior management team has to support.</td>
<td>Benefits from achieving production targets would be shared by all stakeholders. Senior management must ensure that the benefits are achieved instead of creating joblessness.</td>
<td>The family and relations of the senior management would also be happy to see their relatives continuing to be employed.</td>
</tr>
<tr>
<td>The community and country in which ABG operates</td>
<td>‘Does the action, as far as possible, maximise social benefits and minimise social injustices?’</td>
<td>‘Is the action consistent with the moral rights of those whom it will affect?’</td>
<td>‘Will the action lead to a just distribution of benefits and burdens?’</td>
<td>‘Does the action exhibit appropriate care for the wellbeing of those who are closely related to or dependent on oneself?’</td>
</tr>
<tr>
<td></td>
<td>Royalties and job creations are key elements for a good performing company. Taxes paid on revenue from increase production would benefit community and country.</td>
<td>The company has the obligation to meet its guidance in order to pay the projected taxes to the community and government.</td>
<td>Achieving production targets and payment of bonus to the workforce also would create a rippling effect in job creation and businesses in the community.</td>
<td>Taxes and royalties from high revenue will create the appropriate care and wellbeing for the community and country.</td>
</tr>
<tr>
<td>Shareholders and investors</td>
<td>‘Does the action, as far as possible, maximise social benefits and minimise social injustices?’</td>
<td>‘Is the action consistent with the moral rights of those whom it will affect?’</td>
<td>‘Will the action lead to a just distribution of benefits and burdens?’</td>
<td>‘Does the action exhibit appropriate care for the wellbeing of those who are closely related to or dependent on oneself?’</td>
</tr>
<tr>
<td></td>
<td>The Shareholder and investor would benefit from higher production and increased margins.</td>
<td>It is morally right for the shareholder to see that the company is achieving its targets.</td>
<td>The margins created from increased revenue would see the shareholder receiving dividends.</td>
<td>Shareholder margins would be achieved for their investments.</td>
</tr>
</tbody>
</table>
5.3 Conclusion

The answer to the research question was arrived at through a ‘painstaking’ process of interviewing and writing memos throughout the research period and though I had my own perspective on the issues, the insights I gained from some of the interviewees were of great benefit to my understanding of the problem. The combination of the GT, SSM and the memoing helped me to identify the connections and dynamics of the various variables from GT and the SSM process which were put together to arrive at the answers to the question posed dealing with the concerns within the situation.

The ‘i’ in the SCQARiE refers to implementation of the answer; however this was not carried out during the research period, though with the increased concern with the Buzwagi issue, a full reconciliation management process has been outlined based on this research. A similar process was recommended for Tulawaka which has been implemented.

It is recommended that a full implementation of this process be carried out for the other two sites which when implemented would result in the full benefit of this research work for ABG. The implementation of effective reconciliation meetings across the various sites would help in achieving improved reconciliation management processes. The following would have to be set in place:

- The implementation would have to be directed by senior management with the active involvement of the site General Managers supported by the Corporate Technical teams.
- The implementation process would have to ensure that meeting distractions are removed and a high level of participation encouraged. The meeting should be considered one of the strategic functions of the company which should be drafted into the strategic framework as such.
- A small committee would have to be set up for each of the mines to ensure that the meetings are carried out as outlined in the meeting timetable. At the initial stages the committee should understand and review the reconciliation process and monitoring points in the production chain.
5.4 Delimitation of Scope

This research is limited to the gold-mining industry and has been carried out within the ABG mines in Tanzania and the corporate office in Johannesburg. However during the interview process and the Grounded Theory process, people in other Barrick Gold Corporation offices outside Africa (in North America and Australia) were interviewed to gain insight into how reconciliation is managed from those Business units. To increase the scope beyond the realms of Barrick Gold, the assumption made to the data collection was that most of the people interviewed had worked in other mining industries and with those experiences gained; the data would be a representative sampling of how reconciliation is managed, and is supposed to be managed, across the industry. The study also made reference to most papers that have been written from ‘perceived’ authorities in the gold-mining industry. Data collection for the research was carried out through September to December however insights, recording and learning of the two year EMBA programme from 2009 have been used to compile this research.
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SYSTAL (2010)GT Grounded Theory, EMBA 11.4 Course Notes adapted from “Qualitative Research in Nursing” by Helen J Struebert and Dona R Carpenter, Lippincott, 1999


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Appendix

Appendix A – Interrelationship Diagram

The interrelationship diagram was generated using the variable from force field analysis. The use of the ID allows for the identification and classification of the ‘cause and effect’ relationship between the variables causing the downward trend of grades delivered to the plant. Importantly the identification of drivers helps to classify and provide direction to solving the problems at stake. Drivers are the variables that need to be tackled and focused on to achieve an improvement in the outcomes. The process identified team dynamics, interaction and collaboration as the two key drivers that cause the lowering of grade to the plant by way of dilution, ore loss and Mill Recovery.
### Appendix B - Key Selected Literatures for crafting Chapter 2.

<table>
<thead>
<tr>
<th>Level</th>
<th>Concept</th>
<th>Selected Papers</th>
</tr>
</thead>
</table>
Mackenzie, D H and Wilson, G I, (2001), Geological Interpretation and Geological Modelling, in Mineral Resource and Ore Reserve Estimation |
| 3     | Communication & Teamwork | McCarthy, P L, (2001), Mining Dilution and Losses in Underground Mining, in Mineral Resource and Ore Reserve Estimation  
Morley C and Thompson K (2006), Extreme Reconciliation — A Case Study from Diavik Diamond Mine, Canada  
| 4     | Meetings | Fitzsimmons Paul and White Tony (1997) Crossing boundaries: communication between professional groups,  
Conti Betty and Kleiner Brian H (1997), How to increase teamwork in organizations,  
Jarzabkowski Paula and Seidl David (2006), Meetings as Strategizing Episodes in the Social Practice of Strategy,  
Aiken Milam, Hawley Del and Zhang Wenxia (1994), Increasing Meeting Efficiency with a GDSS |
| 5     | Knowledge Sharing | Monnavarian Abbas and Amini Azadeh (2009), Do interactions within networks lead to knowledge management?  
Appendix C – Activities and Interaction of the Reserve Estimation process

The estimation of the grade of a deposit is an iterative process (figure below) that is initiated by exploration and data collection followed by geological interpretation as part of the Mineral Resource estimation. Other non-resource inputs or modifying factors are then considered as the Ore Reserve is estimated. After an operation commences the estimates are managed and modified by the activities of grade control and reconciliation (Appleyard, 2001). It is the last in the process that re-set the entire estimation process again. It is after the reconciliation process that any re-adjustment to the geological modelling, estimation process, mining, modifying factors and risk sensitivity are carried out again. This is a continuous process that would be carried through the mine life.

Dotted lines indicate lower level of participation but it requires input from the professional
Appendix D – Research Design

GOAL
The eventual true value and quality of a mineral resource deposit lies in the reconciliation between the financial returns predicted from the feasibility studies and that actually achieved. The purpose, structure and processes of the Reconciliation should be understood by all personnel involved.

The goal of the research is to understand how the management of the Reconciliation process can be redesigned using systemic approach to improve the Value Adding process of Reconciliation.

Conceptual Framework
Reconciliation is currently being run by geologists and the metallurgists and sometimes discussed with the mining engineers. The results and impacts of the processes are not conveyed to the rest of the team.

Reconciliation has been one of my KPI as the head of Geology and indirectly the Competent Person for the reporting of Resources and Reserves. I will draw on my experience in the subject and the experiences from my colleagues and the wide literature on Reconciliation.

Question
How can systemic approach improve the Mine to Mill Reconciliation process?

Methods
Starting with the Critical realist (CR) view. The data collection stage would start with a one-on-one conversational interviews would be conducted with key personnel in ARG and in the mining industry. The results of the interview would be processed using the GT data processing methodology until the data is saturated. The theoretical coding processes would be carried out to complete the GT processes. SSM would be used to redesign the management process that is systematically desirable and feasible.

Validity
The data collection would be through comprehensive interviews including professionals in the industry not only limited to those in Barrick but with people who works in other mining companies. The GT processes would be carried out from emergence with no preconceive or using any ‘pet categories’. The resulting theory would also be validated through literature reviews.
Appendix E – Concept Map outline for conversational interviewing
## Appendix F – Data Capture

### 1 – List of Interviewees

<table>
<thead>
<tr>
<th>Interview #</th>
<th>Job Title</th>
<th>Company</th>
<th>Location</th>
<th>Interview Type</th>
<th>Date/Received</th>
<th>Consent</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>Snr. Development Geologist</td>
<td>Buzwagi ABG</td>
<td>Buzwagi</td>
<td>Conversational</td>
<td>Sept 15’ 10</td>
<td>Yes</td>
</tr>
<tr>
<td>#2</td>
<td>Snr Mine Geologist</td>
<td>Buzwagi ABG</td>
<td>Buzwagi</td>
<td>Conversational</td>
<td>Sept 15’ 10</td>
<td>Yes</td>
</tr>
<tr>
<td>#3</td>
<td>Mine Production Engineer</td>
<td>Buzwagi ABG</td>
<td>Buzwagi</td>
<td>Conversational</td>
<td>Sept 15’ 10</td>
<td>Yes</td>
</tr>
<tr>
<td>#4</td>
<td>Snr Production Geologists</td>
<td>Buzwagi ABG</td>
<td>Buzwagi</td>
<td>Conversational</td>
<td>Sept 15’ 10</td>
<td>Yes</td>
</tr>
<tr>
<td>#5</td>
<td>Mining Manager</td>
<td>Tulawaka ABG</td>
<td>Tulawaka</td>
<td>Conversational</td>
<td>Sept 18’ 10</td>
<td>Yes</td>
</tr>
<tr>
<td>#6</td>
<td>Chief Geologist</td>
<td>Tulawaka ABG</td>
<td>Tulawaka</td>
<td>Conversational</td>
<td>Sept 18’ 10</td>
<td>Yes</td>
</tr>
<tr>
<td>#7</td>
<td>Snr Underground Geologist</td>
<td>Tulawaka ABG</td>
<td>Tulawaka</td>
<td>Group Discussion</td>
<td>Sept 22’ 10</td>
<td>Yes</td>
</tr>
<tr>
<td>#8</td>
<td>Resource Geologist</td>
<td>Tulawaka ABG</td>
<td>Tulawaka</td>
<td>Group Discussion</td>
<td>Sept 22’ 10</td>
<td>Yes</td>
</tr>
<tr>
<td>#9</td>
<td>Process Manager</td>
<td>Tulawaka ABG</td>
<td>Tulawaka</td>
<td>Group Discussion</td>
<td>Sept 22’ 10</td>
<td>Yes</td>
</tr>
<tr>
<td>#10</td>
<td>Snr Mine Planning Engineer</td>
<td>Tulawaka ABG</td>
<td>Tulawaka</td>
<td>Group Discussion</td>
<td>Sept 22’ 10</td>
<td>Yes</td>
</tr>
<tr>
<td>#11</td>
<td>Snr Mining Engineer</td>
<td>Tulawaka ABG</td>
<td>Tulawaka</td>
<td>Group Discussion</td>
<td>Sept 22’ 10</td>
<td>Yes</td>
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2. Sample Conversational interview transcript using CMap software

Prepositions from the Conversational interview above

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3. Questionnaire and Sample answers

1. In Brief, how should mine to mill reconciliation be managed on a mine?
   It should be driven by a multi-disciplinary group (Mining, Geology, Process, Maintenance and Mine Engineers as well as Survey)) who should be accountable to the General Manager

2. How true is the statement - the mill is always right?
   In the final analysis the evidence of one’s effort is realised in the bullion produced, with very little regard to plant inefficiencies and losses or lock ups. So all deviations are interpreted as a reflection of poor quality material received by the plant.

3. Who should be the custodian of the reconciliation management process?
   The Geology team or Chief Geologist for that matter for reporting purposes

4. Who should be involved in the Reconciliation Process?
   The multi-disciplinary group mentioned above

5. What are the differences between responsibility and accountability?
   The level to which one accepts a position and demonstrates dependability, answerability and accountability is termed responsibility. Responsible people take ownership of their actions and are accountable to their subjects/clients

6. Who should be responsible for ensuring that potential value is not lost along the production chain?
   Various owners of the different levels and activities of the value stream should be responsible for value creation as well as value loss.

7. Usually the person accountable for a process and its results is the one who assesses the various contributions needed from the people involved in the process. In the reconciliation process, who is this person?
   The head of the operation or General Manager

8. Identify the key activities within the mining production chain where reconciliation should be monitored and list which quantities/parameters need monitoring.

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<th>ACTIVITY</th>
<th>MEASURABLE PARAMETER or QUANTITY</th>
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<td>ore waste contact</td>
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<tr>
<td>drilling</td>
<td>deviation, over drills, under drills</td>
</tr>
<tr>
<td>blasting</td>
<td>overbreak, underbreak, secondary blasting</td>
</tr>
<tr>
<td>mucking/tramming/trucking</td>
<td>ore loss, misallocation</td>
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<tr>
<td>stockpiling</td>
<td>blending strategies</td>
</tr>
<tr>
<td>surveying</td>
<td>truck factors, density, volume measurements, swell factors, stockpile depletion</td>
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</table>

9. At what time periods (daily, monthly, quarterly or annually) would you consider the reconciliation process meaningful?
   Monthly recon reviews are useful but proper trend analysis reveal more on a quarterly basis.

10. What benefits are derived from an effective reconciliation management process?
    Clear understanding of departmental roles by the players
    More goal-oriented cohesion at the work place
    Less rework and dilution/ore loss
    Improved reconciliation and realisation of ultimate goals

11. What should senior management do to ensure that the reconciliation process is carried out properly?
    Be involved, demand accountability and provide the necessary support

12. What should be done to improve the Mine to Mill Reconciliation process?
    All of the practices mentioned above – but first and foremost emphasise the multi-disciplinary teamwork approach.
Appendix G

1. Data Analysis

The importance of Mine to Mill Reconciliation in the Production Value chain

- The process would lead to a reduction in Mining Dilution (adding waste to ore).
- Keeping an eye on the value chain to fix any leaks and inefficiencies.
- Setup effective reconciliation method reflective of the mining and processing methods being used.
- Reconciliation should be per process step.
- The benefit of better Reconciliation leads to a transparent accounting standard reconciliation provides checks for discrepancies.
- Reconciliation is about managing a gap between Actual and Predicted.
- Mine-to-mill reconciliations provide invaluable insight into a range of resource and operational factors.
- Good mine-to-mill reconciliation practices deliver outcomes that greatly benefit the management and optimisation of the orebody while reducing uncertainties and risk.
- Reconciliation equates to the comparison of an estimate (resource, reserve and grade control models) with a measurement (information or the official production of the processing plant).
- Mine reconciliation can be seen as the ultimate test of the quality of grade estimates in resource and grade control models.
- Reconciliation is required to validate the Mineral Reserve estimate and allows a check on the effectiveness of both estimation and operating practices.
2 – Substantive Codes
The Substantive codes resulting from the GT process, as framed as variables in the context of the research, are as follows:

(i) The importance of **Mine to Mill Reconciliation** in the production Value Chain
(ii) The need for **Team-based Approach** in the Reconciliation process
(iii) The Effectiveness of **Reconciliation Meeting**
(iv) Degree of **knowledge-sharing** during meetings
(v) The Level of **Feedback** from the Reconciliation management process

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<th>Saturated Categories as variables (Substantive Codes)</th>
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<td>Addressing Change</td>
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(i) **Mine to Mill Reconciliation**
As noted in the earlier chapters of this report, Reconciliation is a process through which the final and ‘true’ value, quality and quantity of a gold deposit can be evaluated from the initial estimates by the geologist to the end of the process when bullion is achieved from the treatment plant. It is about managing the gap between what was predicted at every stage of the production cycle and the actual produced. The process of managing the gap would lead to the identification of problem areas and other areas of concern for a quick solution to be found. The problem areas can only be identified if the process is scrutinised at specific intervals in the production chain. It is always important to perform reconciliations in order to draw conclusions to causes of variations between the predicted and actual before any remedial action can be taken. Poor reconciliations may not simply be a result of errors or misinterpretations in the original resource estimation data and process but can also result from poor grade control, poor mining practices as well as inefficiencies in the processing plant.
The importance of Reconciliation in the production value chain is emphasised by the fact that it helps to know what the losses are and the strategies that needs to be put in place to avert any future failure or loss in revenue and margins for the shareholder. A good mine-to-mill reconciliation practices deliver outcomes that greatly benefit the management and optimisation of the orebody while reducing uncertainties and risk.

(ii) Team-based Approach
A team is defined as a group of people with either mixed or complementary skills working together for an agreed purpose. Performance can be enhanced and obstacles overcome by the synergy of teamwork (Rabey 2003). A strong team is always built on good communication as this will lead to clarity of roles as well as information flow between members. It is important to mention here that in the mining industry, where the workforce is from a diverse cultural background, teamwork is most important as each individual would have to come on board to think that what is being done is taking place in the right direction. The reconciliation processes pass from geologist to mining engineer and then to metallurgist with the surveyor, IT and finance all having an input along the production chain.

Reconciliation should be driven by a multi-disciplinary group for which the geologist, mining engineer and the metallurgist must work together right from the planning stage and throughout the entire process as well as explaining to the non technical members of the team the importance of getting the estimation right.

(iii) Reconciliation Meeting
This meeting is a planned gathering, whether internal or external to an organisation, in which the participants have some perceived roles, have some forewarning of the event, which has itself some purpose or “reason,” a time, place, and, in some general sense, an organisational function (Boden, 1994). The reason for holding an effective reconciliation meeting is to ensure that agreements are reached and decisions to implement any changes in the process are outlined. A meeting is characterised by multi-party talk that is episodic in nature, and participants either develop or use specific conventions (Jarzabkowski and Seidl, 2006) to achieve a high level of cooperation among team members. It is in this period that any problem with the reserve model estimation, metallurgical accounting can be identified and improved.

Such meetings would have to be effective in that whoever leads the meeting would have to have the authority and responsibility to make and take decisions. The meeting would have to fulfil all the requirements of mature communication among team members. The Reconciliation meetings are
strategic in nature and though they are based on operational variances, the solutions and decisions taken affect the long term viability of the mine or operation under discussion. Therefore participation at these meetings is important for each team member to come to the table and contribute his/her portion to the reconciliation process.

(iv) Knowledge Sharing
Knowledge sharing is considered a social contract and is a form of information presented within a particular context, yielding insight on application in that context. Though people can understand information individually and in isolation, it can however be understood only in context, which means through interactivity and communication with others. Interactivity and knowledge sharing are not only integral to “knowing” but are essential for continually evolving knowledge to new plateaus of meaning. “Knowledge can be regarded as the only unique resource that grows when shared, transferred, and managed skilfully (Norris et al, 2003). Sharing knowledge in an organisation creates a pool of strategic stock in the form of dynamic capabilities with which the firm is able to integrate, build, and reconfigure internal and external competences to address any rapidly changing environments (Teece et al, 1997). During the reconciliation meeting, each discipline explains their part of the monitoring which over time gives insight to the others and in this context, knowledge on Reconciliation is shared among the group.

In an industry where people tend to move in and out quickly it is always important that knowledge shared during reconciliation meetings and processes are documented to avoid losing such knowledge when changes take place in the project team. In a work system where teamwork is crucially important, communicating ideas would lead to the efficient running of the reconciliation management process.

(v) Feedback from Reconciliation management
Communication increases knowledge sharing in an organisation and plays a key role in the reconciliation management process but it is made meaningful by means of effective feedback processes. The meetings that are set to discuss reconciliation over a period would be effective if participants contribute to the process by providing the necessary feedback from previous meeting requests and or the outcomes of their evaluation processes. Constructive feedback completes the entire communication process leading to knowledge sharing in that it is the mothers’ milk for improvement and within an organisation. Leaders need to promote the establishment and maintenance of ongoing systems and process-based feedback loops Scholtes (1998). The feedback processes would give members of the reconciliation team an opportunity to adjust and improve on
their performance as the more frequent the feedback is given at meetings, the greater the likelihood that reconciliation performance would be improved.

Whilees feedback closes the communication loop, it also increases the rate at which knowledge is developed and shared in the organisation. Increased constructive feedback also increases the level of interaction in the team which would allow most team members to participate in subsequent reconciliation meetings. Feedback from the management team is also vital to encourage the continuous assessment of the reconciliation processes.

3 – Isomorphic Mapping

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<td>2. Entrepreneurial Invention</td>
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<td>3. Unique Activity set</td>
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<td>4. Competitive Advantage</td>
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<td>5. Results</td>
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<td>7. Distinctive Resources and Competencies</td>
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